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UNITED STATES DEPARTMENT OF AGRICULTURE

DEPARTMENT BULLETIN No. 1329

Washington, D. C. ▼ May, 1925

BAMBOOS: THEIR CULTURE AND USES IN THE UNITED STATES

By

B. T. GALLOWAY

Office of Foreign Seed and Plant Introduction, Bureau of Plant Industry

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INTRODUCTION

Ever since the organization of systematic work in plant introduction in the United States Department of Agriculture more than 25 years ago interest has been maintained in bamboos and their probable uses in this country. We have no native bamboos worthy of the name, our nearest approach to the many varied and wonderful forms of other countries being the Arundinarias of the Southern States. There are two native species of Arundinaria, one the giant cane found in rich alluvial bottoms from Virginia to Kentucky southward and the other the so-called "switch" cane, forming dense brakes and occurring from northern Virginia southward and westward through southern Ohio to southwestern Missouri.

During the past 25 years the Office of Foreign Seed and Plant Introduction has imported into this country more than 60 inventoried numbers of bamboos, representing 12 important genera.

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The major portion of the introductions has naturally come from the Orient, chiefly Japan and China, for it is in these countries that bamboos attain their greatest economic importance. In nearly all of the early systematic agricultural exploration work of the department special attention was given to the bamboos. Knapp, Fairchild, Lathrop, and the late Frank N. Meyer were pioneers in the field. Barbour Lathrop was so impressed with the possibilities of this group of plants in America on this third agricultural exploring expedition, carried on more than 20 years ago, that he caused to be made a special study of Japanese bamboos with a view to their introduction and utilization in the United States. These studies were made by David Fairchild, now in charge of the Office of Foreign Seed and Plant Introduction, and the results were published in the only bulletin (*4*)[1] issued by the department on this subject.

Long before the department inaugurated its systematic work on agricultural explorations, bamboos were being brought into the country in various ways. These unusual and often strikingly beautiful plants naturally attracted the attention of travelers, who found they could be lifted in clumps and kept alive for several weeks. Isolated plantings were thus early established along our southern seacoasts, and some of these have developed in a very striking manner. An interesting case in point is the grove on the Ogeechee Road, 14 miles south of Savannah, Ga. This grove is now more than 30 years old, covers an area of something over an acre, and many of the plants are 50 to 60 feet in height.

Mr. Lathrop's continued interest in the bamboo is shown by the fact that when this remarkable planting of oriental bamboos was called to his attention he purchased it, together with 40 acres of surrounding land, and deeded the property to the Government for plant-introduction work.

It is planned to conduct a large part of the future bamboo propagation and other work at this place. The bamboo found there seems likely to prove one of the best of our cold-resistant giant types, and since further importations of all bamboos in large quantities or for commercial plantings are prohibited, owing to the danger of introducing alien enemies, this grove will likely prove a very valuable asset as a source of propagating material.

Early in 1908, David Fairchild, in charge of the plant-introduction work of the department, inaugurated some extensive measures for bamboo introduction. The services of a man believed to be an expert, W. D. Hills, were obtained in Japan, and he was authorized to get together, grow, and ship to this country a large collection of three or four varieties of the most important economic bamboos. When Mr. Hills had completed his plans he returned to the United States in the autumn of 1909 on an Army transport, bringing 3,500 bamboo clumps with him. The plants were divided into two lots, one being sent to William Tevis, Bakersfield, Calif., and the other to the Plant Introduction Garden at Chico, Calif. This was an instructive but costly experiment, for it showed conclusively that great care is necessary in the handling of such plants.

[1] The serial numbers (*italic*) in parentheses refer to "Literature cited," at the end of this bulletin.

The clumps sent to the Tevis place were planted in the open ground in January, when it was cold, and although the best of care was given them most of the plants died. The Chico shipment was put in a greenhouse and carefully nursed. Heat was supplied and plenty of water given. These plants came through in fair shape, and the bulk of them was shipped to the new garden at Brooksville, Fla., established in 1909 primarily for the purpose of taking care of the bamboo work.

From 1909 to the present time many of the bamboo importations of the department have been sent to Brooksville, but most of them have not thrived there. The soil is unsuited to the needs of bamboos; the temperature variations, especially in winter, are trying; and certain enemies brought in with some of the original shipments have developed to such an extent that it has been deemed unsafe to propagate and distribute the more valuable forms from that place. For the past 10 years, therefore, bamboo culture in this country has been practically at a standstill. A great deal of valuable pioneer work has been done, however, and the real problems confronting the department are better understood. It can no longer look to quantity importations of plants to build up our stocks. The risks in this kind of work are entirely too great; hence the rigid quarantine regulations which have been established.

It appears that most of the forms likely to fit into our economic needs are already in this country. These are widely scattered, and some of them are suffering from certain insects and diseases, probably brought in with them. It is of paramount importance for the future of these crops that the best types for the several economic needs be collected and grown under conditions that will insure clean, vigorous stocks, so that from them mass propagation can be carried on, thus extending the plantations until there is material enough to warrant the encouragement of those who might be interested in the many lines of utilization of the product. The primary object of this bulletin is to call attention to these matters and to indicate some of the lines of action that must be followed to bring about a proper understanding of the economic possibilities of the plants.

In this connection it may be well to say a few words regarding attempts at bamboo culture in regions comparable to some extent to our own Southern and Pacific Coast States. As already pointed out, only two native species are found in the whole of North America. In Europe there are no native bamboos at all. Those found in the southern part of Europe and on the shores of the Mediterranean, in North Africa, and in England have all been introduced. They have been grown, propagated, and studied in these countries for about a hundred years, but so far it can be said they do not play a very important part in the economics of crop production in any of them.

One traveling along the coast of southern France from Hyeres to Cap d'Antibes sees many examples of introduced bamboos in gardens and villas, but they appear to be grown largely for ornament. This is a notable horticultural region, where many tender plants are grown for the markets of Europe and America. Acres of sheds are used for protecting these plants, and millions of stakes are required to hold them upright. The bamboo does not appear to play any part in this development as yet. A partial explanation of the nonuse of

this comparatively new plant material is to be found in the conservatism of gardeners and others, who for generations have been using the native brush for shades, screens, stakes, etc., and do not know how to change.

Another fact which must be kept in mind in any consideration of the economics of its culture and uses is that the bamboo is preeminently a crop that fits into conditions where man labor is cheap and plentiful. In the countries where the bamboo is bound up with the very life of the people and there is scarcely a phase of existence in which it does not play a part, labor counts for little, so that the element of time required in utilization is of minor importance. This is not true of American conditions; we must approach the production and utilization of these crop plants from a different standpoint.

BOTANY OF THE BAMBOOS

Bamboos are true grasses, characterized by hollow or rarely solid stems which are closed at the joints, or nodes. The grass family constitutes one of the most important of all our useful plants. Grasses occur throughout the world, providing food, as in the case of maize, wheat, oats, barley, rice, grain sorghums, and millets, as well as pasturage for livestock of all kinds. When the manifold uses of the grasses and how they enter into practically every phase of man's existence are considered, we can more fully appreciate the Biblical saying "all flesh is grass."

The bamboos constitute one very small group of this immense family, and notwithstanding the fact that they have been known and used from ancient times their botanical characters and relationships are still very little understood. This is due in large measure to the fact that most bamboos are extremely slow in flowering and producing seed. To characterize definitely any species of plant in such fashion that it can be recognized by botanists anywhere requires a study of the essential parts of the flowers and fruits. Some bamboos may grow for 30, 40, or even 50 years without flowering, which is not conducive to a systematic botanical study of the group. Another difficulty presents itself in the matter of collecting and preserving specimens for herbarium studies. Many of the species are so large that securing and preserving good herbarium material is difficult.

A curious and interesting feature of the flowering of bamboos is that when this event occurs many of the species die, so that whole forests pass away, and it requires many years for the seedlings or such parts as escape to repopulate the region. Another phenomenon associated with the flowering of bamboos is the simultaneous development of these organs. Freeman-Mitford (*10*) says, "When the given moment has come every plant of the same kind, whether old or young, over a vast region will put forth its flowers at one and the same moment and, having seeded, the plant disappears."

This peculiarity of the bamboo is of prime importance from an economic standpoint, for it would be unfortunate and discouraging after spending time and money in the development of plantations suddenly to find the whole destroyed or so weakened that years would be required to reestablish them. The danger from this source, however, does not seem to be so great in our country or in southern

Europe as it is in warmer regions. Houzeau de Lehaie, of Mons, Belgium, whom there will be occasion to quote frequently, says (*8*), "For 28 years we have studied bamboos, have grown and cultivated more than a hundred species, and in all that time have seen only eight in flower."

Our own records go back for more than 20 years, and so far as the writer is aware none of the bamboos which are likely to play an important part in an economic way in this country has flowered.

It will not be practicable in a publication such as this to go into details regarding the systematic botany of the bamboos. Suffice it to say that this group of plants belongs to the order of Gramineæ, subfamily Poacoideæ, tribe Bambuseæ. Adopting the systematic arrangement of Camus (*2*), five subtribes are recognized. These are (1) Arundinariæ, (2) Arthrostylidiæ, (3) Chusqueæ, (4) Bambuseæ veræ, (5) Bacciferæ.

In Table 1 there is taken from Camus (*2*) a list of the genera, the number of species in each genus, and the countries where they occur. A list of the department's introductions, which began in a systematic way in 1899, has been added.

TABLE 1.—*Genera of bamboos and number of species of each genus, together with their geographic distribution, and a list of genera and species imported by the Office of Foreign Seed and Plant Introduction*

Name of genus	Number of species	Geographic distribution	Number of introductions
Sasa	12	Central and eastern Asia	11
Oreiostachys	1	Eastern Asia, Malasia	
Arundinaria	81	Eastern Asia, Malasia, Africa, America (a few species)	8
Thamnocalamus	6	Asia, India, China (?), Japan, Africa	
Fargesia	1	China	
Phyllostachys	25	China, Cochin China, India, Japan	17
Microcalamus	1	Tropical and western Africa	
Glaziophyton	8	Brazil	
Arthrostylidium	20	Central America and South America	1
Aulonemia	1	Central America	
Merostachys	18	South America	
Chusquea	71	Central America and South America	3
Planotia	8	do	
Nastus	2	Madagascar, Sumatra, Brazil	
Greslania	4	New Caledonia	
Guadua	29	Central America and South America	1
Guadella	4	Central and western Africa	
Bambusa [Bambos]	73	Central and eastern Asia, Malasia, Australia (one identified species; probably two others not well known).	8
Oreobambus	1	Africa	
Thyrsostachys	2	India	
Gigantochloa	12	Eastern Asia, India, Malasia	
Oxytenanthera	16	Africa, Asia, Malasia, New Guinea	1
Puelia	5	Central and western Africa	
Atractocarpa	1	Congo	
Dendrocalamus	24	Asia, Africa	6
Melocalamus	1	India	
Pseudostachyum	2	do	
Teinostachyum	5	India, Ceylon	
Cephalostachyum	9	Madagascar, India, Malasia	2
Dinochloa	9	Eastern Asia and Malasia	
Schizostachyum	25	Central and eastern Asia, Tahiti, Malasia, Madagascar	1
Melocanna	2	India	1
Ochlandra	11	Central and eastern Asia, Malasia	
Total	490		60

The accompanying list of genera and species, together with the very full descriptions and bibliographical data accompanying the same (Table 1), as arranged by Camus, will prove useful in future

systematic studies of these plants. Camus (*2*) admits that the descriptions are far from complete and that there are necessarily many duplications of names, owing to the absence of characters that are constant and available.

Recognizing the fact that bamboos are in a class by themselves, and that for the most of their lives they present vegetative characters only, attempts have been made to develop a system of classification based largely on vegetative parts, such as the culm sheath, an organ which, as the name indicates, is attached to the culm or stalk; the culms themselves (that is, their shape, size, and methods of growth); kinds of nodes or joints; the branches and branchlets; and the leaves and leaf attachments.

When beginning to study bamboos critically one finds that while their vegetative characters are helpful in a general way they can not be depended upon to separate the multitude of forms which have developed through centuries of vegetative selection in the older parts of the world, where bamboos have been grown and used from time immemorial. Then, again, bamboos will vary greatly vegetatively, according to their environment. Rich soils and poor soils, clay soils and sandy soils, wet soils and dry soils all modify growth and even the shape, size, and appearance of culms, sheaths, branches, and leaves. The vegetative differences are more marked in the young shoots as they come through the ground. It is at this time that differences may be noted that later disappear. Some of these are shown in Plate I, in which eight kinds of bamboo shoots are reproduced from a photograph. Particular attention is called to the shape, size, coloring or spotting, smoothness or hairiness, and various appendages of the culm sheaths. It is by critical comparative studies of these parts, together with studies of the full-grown culms or stalks, the leaves, and the branches and branchlets, that specialists may be able to separate the more important members of the multitude of forms found growing in different parts of the world, and particularly in China and Japan. Most of the readers of this bulletin will not be concerned with these details; the few who are especially interested should consult the comparatively recent work of Houzeau de Lehaie (*8*), who has gone into this subject quite fully.

The bamboos that seem likely to play an economic part in future work in the United States are few in number. This does not include a considerable collection of ornamental species and forms, which must also have consideration, but in a different way from those likely to be grown in large areas and utilized for many domestic and commercial purposes.

CULTURAL TYPES

The cultural characters of some of the more important bamboos tested during the past 15 or 20 years and found adapted to the climate and soil of our South Atlantic, Gulf Coast, and certain of the Pacific Coast States will be described here. Naturally, a large number of tropical and subtropical forms are excluded, as they can not withstand our winters. The field of promising and potentially economic bamboos, therefore, is limited to a comparatively few species and forms found mostly in those parts of China and Japan corresponding in climate to the regions indicated above. This statement

does not apply to a number of bamboos valuable for ornamental planting and landscape adornment. These striking and beautiful plants, it is believed, will play a more and more important part in outside decorative work, but their uses in this field are so specialized that they necessarily must be treated separately. We are concerned now with the species and forms likely to prove of widespread value for utilitarian purposes as distinguished from æsthetic utilization.

There are four genera, found mostly in temperate parts of the globe, that will supply this country with its chief source of crop material. In the order of their economic importance they are Phyllostachys, Bambos, Sasa, and Arundinaria. Representatives of other genera may play an incidental part, but their economic value in comparison with those mentioned will be more or less negligible. Representatives of these several genera will be described in such a way that it is hoped they can be recognized and their place in future work understood.

GIANT TIMBER BAMBOO

(*Phyllostachys bambusoides* Sieb. and Zucc.)

For reasons not well understood this particular bamboo seems to have been born to nomenclatural trouble. In the department's records for 20 years it is referred to under half a dozen different names, sometimes one thing, sometimes another. Houzeau de Lehaie devoted about 10 pages of his monograph (*8*) to an effort to straighten out the synonymy of this species and to explain why it has been given so many names and described as being anything from a shrub 8 to 10 feet high to a tree growing from 50 to 60 feet tall. The giant timber bamboo, *Phyllostachys bambusoides*, as we know it and have established it in this country, has been variously referred to as *P. quilioi*, *P. henonis*, and *P. micrantha*. These are now regarded as belonging to the same species, *P. bambusoides*, originally described by Siebold and Zuccarini.

Good examples of this fine bamboo are to be found growing in the grove in the Plant Introduction Garden at Chico, Calif., the Barbour Lathrop grove in the Plant Introduction Garden near Savannah, Ga., the groves in the Brooksville, Fla., Plant Introduction Garden, and the grove owned by William S. Tevis, near Bakersfield, Calif. These groves are from 14 to 35 years old and have been under observation sufficiently long to furnish very reliable data on the character, habits, and hardiness of the plants. No plants of the giant timber bamboo have flowered in this country. (Pl. II.)

Briefly described, *Phyllostachys bambusoides* presents the following vegetative characters:

Height 20 to 70 feet; stems, or culms, straight, smooth, 2 to 5 inches in diameter, flattened on one side in alternate internodes, the flattening being more pronounced in the smaller and younger culms, green at first, becoming yellow with age; many culms in the grove at Brooksville marked three years ago are still green, showing that ripening and maturing are relatively slow processes; nodes, or joints, prominent, smooth; internodes varying in length from 6 to 14 inches, shorter near the ground; culm sheaths varying in length from 2½ to 14 inches, depending on the age and size of the plants, 1½ to 3 inches wide, thin and often mottled and blotched with purplish or brownish spots, many nerved, mouths rounded and provided with scattered stiff hairs capped with a long narrow limbus or pseudophyll. (Pl. I; S. P. I. No. 24760.)

Branches borne in pairs from the nodes, each alternate branch being larger and longer than the one below; leaves varying in size, 4 to 8 inches long, one-half to three-quarters of an inch wide, bright green above, grayish below, edges sharply serrated on one side with 5 to 7 secondary nerves on either side of the midrib.

The giant timber bamboo promises to be one of our most valuable forms. It is hardy and from the evidence at hand will succeed well in suitable soil and under proper care in all South Atlantic and Gulf Coast States; also in portions of southern Arkansas, California, and Oregon. It is a comparatively rapid grower and spreads easily and quickly by means of its extensively creeping rhizomes.

STAKE AND FORAGE-CROP BAMBOO

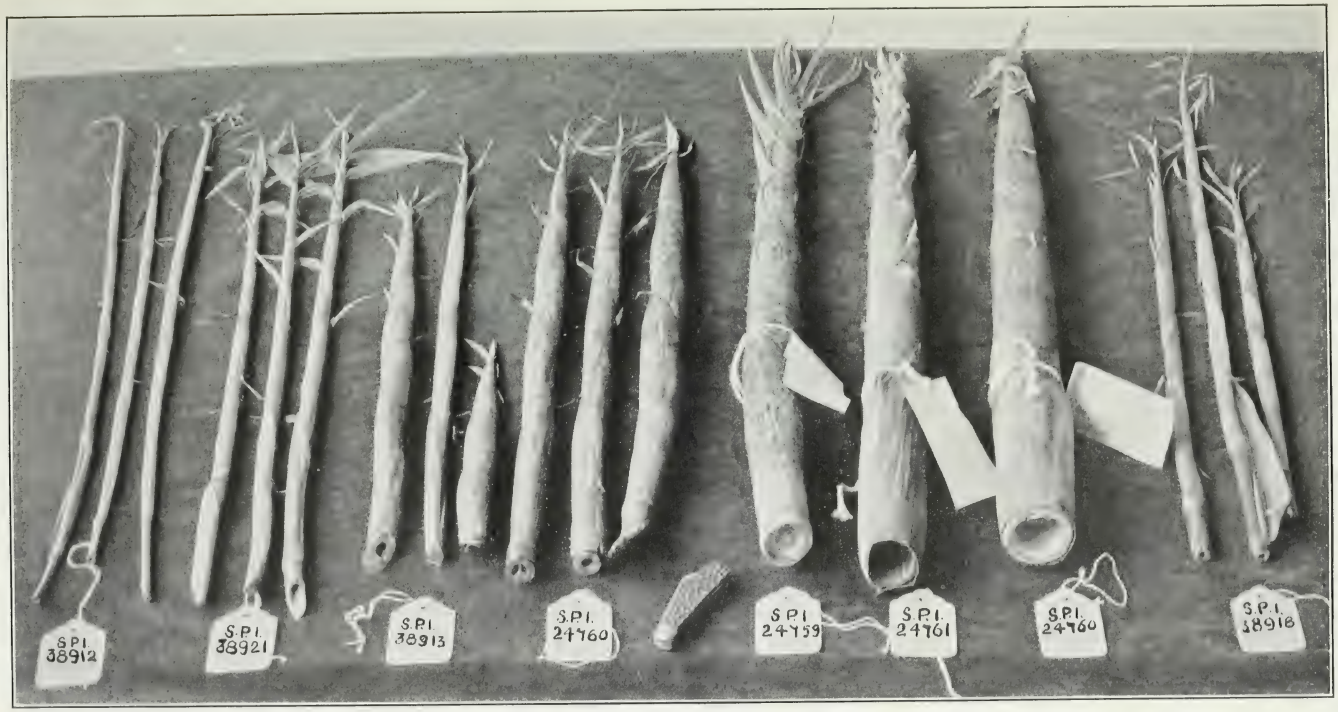
(*Phyllostachys nevinii* Hance)

In the spring of 1907 the late Frank N. Meyer, Agricultural Explorer, collected a number of hardy dwarf bamboos in the vicinity of Peking, China. Later in the same year he collected 8 or 10 additional bamboos near Tangsi, about 800 miles south of Peking. These bamboos were assembled at Shanghai and kept there until the spring of 1909, when Mr. Meyer brought them to this country and placed them in the Plant Introduction Garden at Chico, Calif. Among the collections made were two lots, doubtless from North China, which have borne separate plant-introduction inventory numbers and have been grown and distributed as distinct forms. These are S. P. I. Nos. 23233 and 23261. The descriptions of these forms sent in by Mr. Meyer were meager, and their behavior here does not conform to the published notes. For this reason one of the forms, S. P. I. No. 23233, was given a new number, S. P. I. No. 55713, and the description was modified to indicate the size of the plant.

It would appear from a careful study of these two forms that they are identical and except for their dwarfish habits resemble somewhat *Phyllostachys bambusoides.* The stake and forage-crop bamboo has two characters deserving special notice. These are the freedom of the plant from the attacks of a mite, a small, almost microscopic creature introduced from Japan which has given the department much trouble, and its apparent ability to resist a rust, a new fungous parasite related to the rust on wheat which appeared at Brooksville three or four years ago and has spread rapidly. *Phyllostachys bambusoides* is badly attacked by both of these enemies, while *P. nevinii* is mostly free from mite infestation and shows no evidence of rust, although growing in close proximity to badly rusted plants of *P. bambusoides.* Other characters would lead to the belief that in these two forms there is a distinct species, first described by Hance in 1876. (Pl. III.)

For a number of years one of these bamboos, S. P. I. Nos. 23233 and 23234, has been carried in the department records as *Phyllostachys nevinii hupehensis* Rendle. This is now believed to be an error, as S. P. I. Nos. 23233 and 23261 conform more closely to the rather meager descriptions of the true *P. nevinii,* while S. P. I. No. 23234 does not agree with either of the descriptions.

The two forms have been grown and propagated by the Office of Foreign Seed and Plant Introduction for 15 years and have been rather widely distributed. *Phyllostachys nevinii* (S. P. I. No.



YOUNG BAMBOO CULMS, SHOWING THEIR APPEARANCE AS THEY COME THROUGH THE GROUND, TOGETHER WITH SOME OF THE MORE IMPORTANT CHARACTERS OF THE CLASPING CULM SHEATHS

Note the mottling or spotting of some of the sheaths, the hairiness and smoothness of others, and the shape, size, and length of the points at the ends of the clasping culm sheaths. S. P. I. No. 24759 is the edible bamboo of Japan (*Phyllostachys edulis*) with a hairy sheath. S. P. I. No. 24760 is the timber bamboo (*Phyllostachys bambusoides*), the sheaths of which are smooth and spotted

TYPICAL GROVE OF THE GIANT TIMBER BAMBOO

This is the Barbour Lathrop grove (*Phyllostachys bambusoides*), near Savannah, Ga. It is now about 35 years old. Note the clean, straight culms and nodes close together near the base but farther apart higher up

THE STAKE AND FORAGE-CROP BAMBOO

This bamboo (*Phyllostachys nevinii;* S. P. I. No. 55713) grows 15 to 18 feet high and produces an almost impenetrable thicket. It is valuable as a forage crop, for stakes, and many other purposes

FIG. 1.—YOUNG SHOOTS OF THE STAKE AND FORAGE-CROP BAMBOO

This bamboo (*Phyllostachys nevinii;* S. P. I. No. 55713) has many-veined clasping culm sheaths and pointed pseudophyls with hairy throats. Compare with Figure 2 and note the differences in shape of sheaths, apex, etc.

FIG. 2.—YOUNG SHOOTS OF THE DWARF HARDY BAMBOO

This bamboo (*Phyllostachys* sp.; S. P. I. No. 23234) has clasping culm sheaths with tapering apexes and long slender pseudophyls

55713) as grown in the United States shows the following important vegetative characters:

Culms 8 to 15 feet high, straight, tough, hard, and flexible, and of a golden yellow color, sometimes approaching green, markedly flattened between the nodes with a ridge running through the flattened part; nodes, or joints, prominent with a rather sharp flaring rim above, dark smoky brown; internodes 6 to 10 inches long, shorter near the ground; branches in pairs from each joint, each alternate branch longer and larger than its twin, yellowish like the culm, wiry, and tough; leaves mostly single, on ends of slender purplish branchlets, slender, with five pairs of secondary veins on each side of the midrib, 3 to 3½ inches long, one-third to one-half inch wide, glossy and shiny on the upper side, grayish or glaucous beneath, petiole short, base rounded, apex gradually tapering, often sharply acuminate; leaf sheaths dry, coriaceous, persistent, smooth, brownish, and frequently covered with faint smoky dark spots; mouth of leaf sheath not hairy; rhizomes slender, many jointed, pale yellow, and extensively creeping.

Young culm sheaths on emerging from the ground are of a beautiful purplish color. At first the shoots are completely covered by the purplish many striped culm sheaths. These clasp the culm firmly and are smooth except along the edges, where they are clothed with very fine glistening hairs.

The culm sheath is tipped with a long, narrow, tapering purplish appendix, or pseudophyll, at the base of which are two winglike attachments, the auricles, tipped with several tentaclelike purple hairs. The ligule firmly clasps the sheath above it and is short, purplish, with a wavy margin. When the culms get about 2½ feet high the sheaths are no longer present, so that the joints below as they emerge from the ground are smooth, green, and shiny.

This bamboo is a vigorous grower and readily adapts itself to any one of a variety of soils. It is hardy and will grow without serious injury from frost in almost any South Atlantic or Gulf Coast State; also in many parts of the Pacific coast region. Its uses are manifold, as will appear later in this bulletin. See Plate III for an illustration showing the general appearance and habits of this bamboo; also Plate IV, Figure 1, showing culm sheaths and their botanical characters.

DWARF HARDY BAMBOO

(*Phyllostachys* sp.)

The dwarf hardy bamboo is doubtless one of the forms found by Mr. Meyer near Peking, although in his notes it is credited to Tangsi, 800 miles farther south. It has been distributed under S. P. I. No. 23234 and called *Phyllostachys nevinii hupehensis*. It is evident that this bamboo is a distinct form and one which does not seem to have been described. Without flowers and fruits it would be undesirable to give the plant a species status; therefore, it has been designated for the present as *Phyllostachys* sp. (Pl. IV, fig. 2.) It presents the following vegetative characters:

Culms straight, firm and tough, moderately thick walled, 8 to 15 feet high, greenish yellow, often marked with dark smoky blotches; nodes prominent, slightly fistulous, differing in this respect from *Phyllostachys nevinii*, surrounded by a narrow grayish black band; internodes short, 4 to 6 inches long, flattened on alternate sides with a ridge running through the flattened portion; branches numerous, clothing the culms from top to bottom, proceeding from the nodes in pairs, of nearly the same length, therein again differing from *P. nevinii*, which has one branch smaller than its twin; branches rigid and tough, flattened between the joints; branchlets slender, wiry, usually a single one from each joint; leaves usually in threes, sometimes in fours, narrow, 3 to 4 inches long; midrib prominent, usually with 5 or 6 pairs of secondary nerves which show prominently on both upper and lower surfaces, dark green with little difference in color between upper and

lower surfaces; leaf sheaths persistent, greenish, smooth, mouth covered with downy hairs; ligule downy, firmly clasping the sheath, upper margin wavy; auricles small; culm sheaths greenish yellow, sometimes tinged with pink, thin, firmly clasping the culm, smooth, faintly veined, tipped with a narrow pseudophyll varying in length from 1 to 4 inches; throat of sheath smooth, ligules short, blunt, smooth. The young culms with their clasping sheaths are quite different from those of *P. nevinii*, particularly in the absence of the tentaclelike hairs at the mouth and the color, size, and shape of the pseudophyll. (Pl. IV, figs. 1 and 2.)

A strong-growing type with extensively creeping, slender, many jointed, wiry rhizomes. The rhizomes soon form almost a solid mat in the soil, sending up many shoots, forming a dense thicketlike growth. Unlike *P. nevinii* this bamboo is subject to the attacks of both mites and rust. A hardy type likely to prove useful for many purposes.

HAIRY SHEATH EDIBLE BAMBOO

(*Phyllostachys edulis* (Carr.) H. de Lehaie)

There has been much confusion over the botanical name of this fine bamboo. It was originally described by Carrière (*3*) in 1866 as *Bambusa edulis*. Houzeau de Lehaie (*7*) first placed the species in the genus Phyllostachys under the name *P. pubescens*, but later adopted Carrière's name. Camus (*2*, p. 59) uses *P. pubescens*, but inasmuch as *P. edulis* has priority it would seem best to follow De Lehaie.

The Office of Foreign Seed and Plant Introduction has been active in efforts to introduce this bamboo. It is propagated with some difficulty, and although the department's records show nearly a dozen different importations, extending back 15 years or more, it is not established at any of its gardens. Good examples of this bamboo are to be found on the place of Rufus Fant, Anderson, S. C.; also on the plantation of E. A. McIlhenny, Avery Island, La. The Anderson plantings are now about 32 years old. At Mr. Fant's place there are four separate groves, averaging about 30 by 100 feet. The culms have now reached a height of 40 to 50 feet. (Pl. V.)

According to Dr. David Fairchild, who visited Mr. Fant's place and made some studies of this bamboo in November, 1918, Mr. Fant obtained the bamboo from a firm in San Francisco, Calif. He kept the plant in a pot for seven or eight years, for fear it would be winterkilled if left out of doors. When planted out it grew well and soon began to spread. In 1912 Mr. Fant decided to start a grove along a little stream which runs through a cemetery not far from his home. He took up a clump and planted it in the cemetery. In six years this clump had developed into a grove, with 266 canes about 30 feet high. In February, 1918, there was a severe freeze, the temperature falling to 2° F. Some of the canes were cut back but soon were normal again. This is interesting and important as showing quick recovery after hard frosts.

The groves at Mr. McIlhenny's place are from plants imported by the United States Department of Agriculture in 1909, and they have thrived.

This bamboo has many uses in the Orient but is prized chiefly for its edible shoots. (Pl. VI.) A description follows:

Culms 10 to 100 feet in height, 4 to 6 inches in diameter, gently curved on leaving the ground, at first deep green with a velvetlike covering of very short hyaline hairs which soon wither away, leaving the culms grayish, yellowish, or orange below the nodes; the second year the culms become darker yellow and develop permanent waxy surfaces; culms conical at the base, gently tapering

above with arched tops; internodes short at the base of the culm, longer above, where they have distinct channels on the side opposite to those caused by the pressure of the branches; branches solid, usually horizontal, borne in pairs; branchlets small, golden yellow after the first year; leaves small, linear-lanceolate, edges slightly serrated, abruptly contracted into a short petiole, pale green, becoming yellowish with age, borne in pairs, rarely in threes and fours, at the ends of the branchlets; culm sheaths quite striking in appearance when the shoots appear, thick and covered with brown hairs, which are first soft, then harsh and brittle after drying, causing irritation if they come in contact with a mucous membrane. At the base of the culms the hairs cover the sheaths entirely, but higher up they are not so thick, so that through them can be seen the yellowish color of the sheaths with dark-colored or black patches, which become more numerous and run together near the pseudophyll. The ligule is very small, brown, and fringed, and the pseudophyll is triangular at the base, 10 to 15 centimeters long on the upper sheaths, channeled, and erect. (Pls. V and VI.)

SMOOTH-SHEATH EDIBLE BAMBOO

(*Phyllostachys mitis* A. and C. Rivière)

This valuable bamboo is rare in the United States; in fact, it is questionable whether it is growing anywhere in this country. It was introduced by the Office of Foreign Seed and Plant Introduction in 1920 but failed to grow. Fairchild's (*4*, p. 27) description of this species applies to *Phyllostachys edulis*, and the same is true of the description given by Makino (*9*, p. 68). The chief points of difference between *P. mitis* and *P. edulis* follow: *P. mitis*, culms always glabrous or smooth, nearly cylindrical at the base with long internodes, culm sheaths smooth, branches hollow, leaves large. *P. edulis*, culms pubescent or hairy with short internodes, culm sheaths tomentose or hairy, branches solid, leaves small.

The smooth-sheath edible bamboo is one of the largest and most hardy in China and Japan. It was introduced and has been grown for a good many years in the south of Europe and in Algeria, where it is highly regarded as a very useful form. Its most important characters may be set forth as follows:

Culms 25 to 50 feet high, 4 to 5 inches in diameter, straight, deep green and shiny at first, later becoming bright yellow; branches numerous, two at each node, clothing the entire culm; leaves variable in size, 1 to 6 inches long, lanceolate, tapering to a very fine point and ending at the base in well-defined petioles, one edge serrated, showing scattered coarse hairs where the blade enters the sheath; culm sheaths enveloping the culm for the whole of its length, smooth, yellowish straw color, spotted with brown or chestnut colored patches, more numerous near the top, mouth provided with a narrow fringed ligule, tipped with a pseudophyll variable in size and often variegated with yellow or orange stripes. The rhizomes are fairly active, but do not spread so rapidly as those of *P. bambusoides*.

VARIEGATED PHYLLOSTACHYS

(*Phyllostachys bambusoides castilloni* (Marl.) H. de Lehaie)

This beautiful form of the giant timber bamboo (*Phyllostachys bambusoides*) has been introduced a number of times, but it is seldom found in cultivation. It has been at the Brooksville garden a number of years but never seemed very aggressive and gradually died out. Some of the best specimens of the variegated Phyllostachys at Brooksville have been in clumps of *Bambos vulgaris*, having probably found their way there when the plants were grown together in the nursery. This variegated form has all the characters of *Phyllostachys bambusoides*, of which it is doubtless a sport.

The variegation is probably an element of weakness, so that to find the form as aggressive and vigorous as its parent would not be expected. It likely will not have any special value for commercial purposes but may prove useful in other ways, which will be pointed out later.

CALCUTTA FISH-ROD BAMBOO

(*Bambos tulda* Roxb.)

This is one of the most striking and useful of all the bamboos, but unfortunately it stands but little frost and can be grown successfully only in the warmer parts of the United States. There are large tracts on the west coast of Florida south of Tampa where this bamboo ought to prove successful. It should thrive also in other parts of Florida south of latitude 28 where the soil is suitable and rainfall abundant. The plant may be grown readily from seeds, which is a great advantage in establishing plantations quickly. At the Brooksville Plant Introduction Garden this bamboo has done fairly well, although injured some by frost nearly every year. (Pl. VII, fig. 1.) One year, 1916, nearly 6 bushels of seeds were obtained from India, and notwithstanding certain quarantine restrictions which made it necessary to hold the seed seven or eight months, most of it grew when planted.

Bambos tulda has been known for nearly a hundred years, having been described first in 1832 as occurring in India (*12*, p. 193). It has been widely distributed, especially in all the warmer regions of the earth. Beautiful and striking plantings of this species occur in the Canal Zone. Henry Nehrling has grown some fine specimens at Gotha, Fla. In 1917 and 1918 culms of this bamboo reached a height of 65 feet on Mr. Nehrling's place but were frozen to the ground. This variety differs from many other bamboos in that the culms are nearly solid and very heavy. On a plat at Brooksville where the culms are 14 to 16 feet high, the yield was estimated at 35 to 40 tons per acre. (Pl. VII, fig. 2.)

J. S. Gamble has given such an excellent description of this bamboo (*5*, p. 30) that we quote the same in full:

> An evergreen or deciduous, cæspitose, arboreous, gregarious bamboo. Culms green or glabrous when young, gray-green when older, sometimes streaked with yellow, 20 to 70 feet high, 2 to 4 inches in diameter; nodes not swollen, the lower ones fibrous-rooted; internodes 1 to 2 feet long, white-scurfy when very young, ringed with white below the nodes; branches many from nearly all nodes, those of lowest ones thin, nearly leafless, horizontal. Culm sheaths about 6 to 9 inches long, 6 to 10 inches broad, smooth or whitish powdered or covered with appressed brown hairs without, often white-powdered within; slightly attenuate upwards and rounded or triangularly truncate at top; imperfect blade broadly triangular, reniform or cordate, cuspidate, erect, hairy within, the base decurrent into rounded, large, long-fringed auricles, or a wavy narrow-fringed band along the upper edge of the sheath; ligule narrow, entire. Leaves linear-oblong or linear-lanceolate, 6 to 10 inches long by 0.7 to 1.5 inches broad; usually rounded at the base into a short 0.1 inch, often hairy petiole; acuminate above in a subulate twisted point; glabrous above, except for the scabrous veins near the margin on one side, glaucescent and puberulous beneath; scabrous on the edges; main vein rather narrow, secondary veins 6 to 10, intermediate 7 to 8, pellucid glands faint, scanty; leaf sheath striate, glabrous, ending in a smooth callus and an oblong rounded auricle, fringed with long, thin, whitish bristles; ligule narrow, inconspicuous. Inflorescence variable, sometimes an immense radical leafless panicle, sometimes a short leafy paniculate or spicate branch; branches spicate, bearing

interrupted clusters of few (1 to 5) usually fertile long spikelets, supported by shining chaffy bracts; rachis smooth, striate. Spikelets variable in length, 1 to 3 inches long, 0.2 inch broad, sessile, glabrous, cylindrical and acute at first, afterwards divided into many flowers separated by conspicuous rachillæ, bearing first 1 to 2 short bracts, then 2 to 4 usually gemmiparous empty glumes, then 4 to 6 fertile flowers, and finally 1 or 2 imperfect or male terminal flowers; empty glumes acute, many-nerved; flowering glume many-nerved, glabrous, striate, 0.5 to 1 inch long, 0.3 inch broad, ovate acute or acuminate, mucronate, sometimes minutely ciliate on the edges; palea rather shorter, boat-shaped, 2-keeled, with long white ciliæ on the keels and penicillate at the tip, 5 to 7 nerves in the hollow between the keels; rachillæ clavate, flattened, striate, glabrous except on the ciliate tip and occasionally the faintly ciliate edges, articulate below the glumes, so that the spikelet readily breaks up. Lodicules 3, 0.15 inch long, two cuneate, oblong, obliquely truncate thickened and fleshy below, especially on one side, hyaline and about 5-nerved above, the upper part long-white fimbriate; the third not thickened, hyaline, acute, long-fimbriate. Stamens long exserted, anthers 0.3 to 0.4 inch, purple, glabrous, blunt at the tip or emarginate. Ovary obovate-oblong, white, hairy above, surmounted by a short hairy style which is early divided into 3 long plumose wavy stigmas. Caryopsis oblong, hirsute at the apex, furrowed, 0.3 inch long.

Central and Eastern Bengal, Assam and Burma, also in the hills of the Northern Circars (if I am right in considering the common gregarious bamboo of the hills of the Golgonda Agency in the Vizagapatam district to be this species), and probably in those of Orissa. It is cultivated all through Eastern Bengal and Burma, and is probably the most common kind in the Lower Bengal rice country and in the Assam valleys.

NAKED-CULM CLUMP BAMBOO

(*Bambos vulgaris* Schrad.)

This is a very old species, having been described first in 1810. It is widely disseminated through the warmer portions of the globe and was doubtless in cultivation many years before it was described by botanists. Its widespread occurrence and variations in form have resulted in its being described many times; hence the list of synonyms for the plant is a formidable one. A feature about this bamboo that is quite noticeable is the presence of numerous leafless culms, these being the last ones formed. Some types of this bamboo are almost tropical in their tenderness; others will withstand considerable frost. The Office of Foreign Seed and Plant Introduction has made several importations of this plant during the past 15 years and has some fine specimens of it growing in the Brooksville garden.

Bambos vulgaris is fairly well disseminated in Florida and parts of California, as it was one of the forms early brought in by florists, seedsmen, and amateur plant growers. It is believed to be a native of the island of Madagascar and was introduced early into northern Africa and the regions of southern Europe along the Mediterranean Sea. (Pl. VIII.) A. and C. Rivière (*11*), in their book on bamboos, give a long account of its growth. The form the department is growing at Brooksville has withstood temperatures as low as 18° F. without serious injury. This form is often met under the name Bambos or *Bambusa thouarsii*. While *Bambos vulgaris* is an ornamental bamboo, it will also have its place in a utilitarian way on the farm and around the home. The culms are strong and heavy, and while they do not last long when cut they may be made to serve many useful purposes. The plant may be characterized as follows:

Culms growing in clumps 20 to 50 feet high, bright green or yellow and striped green and yellow; naked at first except for the striking culm sheaths, 2 to 4 inches in diameter, often zigzag or bent near the ground, walls thick, rather

soft, especially when young; nodes not prominent, narrow, grayish at first, becoming greenish as the culm grows yellow with age; internodes 8 to 18 inches in length, shorter below; branches slender, wiry, emerging in alternate tufts from the nodes and clothing the culm for most of its length with foliage, one or more branches of the tuft stronger and longer than the others; leaves linear-lanceolate, bright green above and below, 6 to 8 inches long, three-fourths to 4 inches wide; culm sheath 6 to 12 inches long and sometimes 8 to 10 inches wide, clothed on the upper surface with thick brown hairs; rhizomes short, thick, and gnarled, not running. The internodes in Plate XIII show the characteristic habit of this plant; also the culm sheaths, naked culms, etc. (Pl. VIII.)

AVAILABLE AND PROSPECTIVE TYPES

The foregoing constitute the important bamboos suitable for commercial and domestic use in this country. The list is not a long one, but it gives range enough to meet our immediate needs. Further introductions will necessarily be slow except where it is possible to obtain seeds, so that for some time to come we must be content with bringing into wider use the forms which are already available and waiting to be properly exploited.

Further data on potential and prospective useful types will be found in connection with the discussion and descriptions of ornamental bamboos.

USES OF BAMBOO

The uses of the bamboo in the parts of the world where it flourishes are so numerous that to catalogue them would make a volume. It has been well said that there is not in the entire vegetable kingdom another plant which is so intimately bound up with the life of man. This applies especially to the thickly populated parts of China, Japan, India, Ceylon, and Java. In the last-named country, only a little larger than Cuba and with a population of nearly 30,000,000, the bamboo is so woven in with the life of the natives that it is doubtful whether they could long exist without it. On that wonderful island, where everything grows so luxuriantly, the bamboo lends an indescribable charm to the landscape. In the cool of the evening, after the usual daily tropical rain, one may stand on an eminence overlooking lovely valleys, and the landscape for miles will be seen dotted with clumps of most wonderful bamboos. From beneath all these clumps the natives begin to emerge, and soon the banks of the stream are alive with bathers dressed in their gay-colored sarongs.

Nearly every bamboo clump shelters a little native thatched hut or two. These picturesque homes blend so wonderfully into the bamboo frondage that it is difficult to see them at all from above.

Freeman-Mitford, in his fascinating book (*10*), speaking of the uses of the bamboo in China and Japan, says:

> To the Chinaman, as to the Japanese, the bamboo is of supreme value: indeed, it may be said that there is not a necessity, a luxury, or a pleasure of his daily life to which it does not minister. It furnishes the framework of his house and thatches the roof over his head, while it supplies paper for his windows, awnings for his sheds, and blinds for his veranda. His beds, his tables, his chairs, his cupboards, his thousand and one small articles of furniture are made of it. Shavings and shreds of bamboos are used to stuff his pillows and mattresses. The retail dealer's measures, the carpenter's rule, the farmer's water-wheel and irrigating pipes, cages for birds, crickets, and other pets, vessels of all kinds, from the richly lacquered flower stands of the well-to-do gentleman down to the humblest utensils, the wretchedest duds of the very poor, all come from the same source.

The boatman's raft and the pole with which he punts it along: his ropes, his mat-sails, and the ribs to which they are fastened; the palanquin in which the stately mandarin is borne to his office, the bride to her wedding, the coffin to the grave; the cruel instruments of the executioner, the lazy painted beauty's fan and parasol, the soldier's spear, quiver, and arrows, the scribe's pen, the student's book, the artist's brush and the favorite study for his sketch; the musician's flute, mouth-organ, plectrum, and a dozen various instruments of strange shapes and still stranger sounds—in the making of all these the bamboo is a first necessity. Plaiting and wicker-work of all kinds, from the coarsest baskets and matting down to the delicate filigree with which porcelain cups are encased—so cunningly that it would seem as if no fingers less deft than those of fairies could have woven the dainty web—are a common and obvious use of the fiber. The same material made into great hats like inverted baskets protects the coolie from the sun, while the laborers in the rice fields go about looking like animated haycocks in waterproof coats made of the dried leaves of bamboo sewn together. See at the corner of the street a fortune-teller attracting a crowd around him as he tells the future by the aid of slips of bamboo graven with mysterious characters and shaken up in a bamboo cup, and every man around him smoking a bamboo pipe.

See in yonder cook-shop the son of Han regaling himself with a mess of bamboo shoots, which have been cooked in a vessel of the same material coated with clay, and are eaten with chop-sticks which may have grown on the same parent stem. Such shoots, either in the shape of pickles or preserved in sugar, are an article of export from south to north, where they are esteemed a delicacy.

It is impossible to foresee what the future has in store for the bamboo in this country. That this group is worthy of serious study and effort is beyond question. Who knows but some day these giant grasses may play an important rôle in our welfare. As our forests disappear and the need is more and more felt for quick-growing and easily worked wood material the bamboo may find an important place here, as it has found a vital niche in the countries of the Old World. The plant is preeminently oriental and when transplanted elsewhere behaves as if it were not entirely happy. It is more than likely that we do not possess that sympathetic inherent knowledge necessary to get the most from the plants; we have not known them long enough. This is certainly true when it comes to utilization, for it must be admitted that we are woefully ignorant as to the proper way to prepare and use the parts of the plants we have grown. This work is evidently a fine art, for it is hardly conceivable that climate and soil could so modify the plants as to make them unfit for the multitude of purposes for which they are used at home.

In England and southern Europe, where the bamboo has been cultivated much longer than here, little is known regarding its utilization. Volumes have been written on the culture of bamboos in Europe, but we have yet to find very much of a definite nature regarding the commercial or domestic utilization of the home-grown product. Freeman-Mitford says that it is to be regretted that a plant so rich in economic value in its native home is suitable only for ornament in England. He consulted a leading umbrella manufacturer of London, who told him that he found the bamboo canes from the south of France unfit for umbrella handles on account of their brittleness and liability to split. He adds that it is hard to think that out of such a wealth of material Europe can not even achieve the humble triumph of an umbrella handle.

This country has many advantages over England in a wider range of soil and climate, and some of the bamboos have been grown long enough to warrant the belief that aside from their future potential

value they have uses here which will make their cultivation for certain purposes well worth while.

An endeavor will now be made to point out as specifically as practicable some of the more important of these uses, dealing with domestic uses first, as it is evident that these will lead the way to more extended or commercial utilization.

FARM-HOME GROVES

In the territory with which we are concerned, including the South Atlantic, Gulf Coast, and Pacific Coast States and some of the States of the lower Mississippi Valley where the bamboos that have been described will thrive, there are something over 3,000,000 farms. A farm, as defined by the United States Bureau of the Census, is all the land which is directly farmed by one person, managing or directing agricultural operations, either by his own labor alone or with the assistance of members of his household or hired employees.

Upon many thousands of these farms there are opportunities for the development of small bamboo groves of an acre or two in extent. There are no good reasons why most of these farms should not have such groves. The giant timber bamboo and one or more of the smaller growing kinds, such as the stake bamboo, would be most valuable for these farm-home groves. These groves if properly handled in the course of years would prove not only a source of profit but would be the means of providing many conveniences for the farm and home, such as those mentioned in the following paragraphs.

Light fences.—It is often desirable to fence off temporarily a piece of ground for a cow pasture or some other purpose when one does not want to go to heavy expense. Bamboo poles lend themselves admirably to the construction of such fences. The poles are quickly cut and easily handled. Using poles 1½ to 2 inches in diameter and 20 to 25 feet long for stringers and poles 7 feet long and 2½ inches in diameter for posts, two men can fence in an acre of ground in a few hours. Holes for the posts may be made 2½ feet deep with a post-hole digger or auger, and the stringers may be lashed to the poles with bale wire. The posts may be set 10 feet apart.

Many modifications of such a fence may be made, including chicken and rabbit proof structures, using slender poles as pickets. Nails can not be used for such work, for they split the poles. This is one of the objections to bamboo and the use of bamboo materials in many kinds of construction work. Americans are so accustomed to the use of wire nails that they find it difficult to adopt other and more laborious methods of holding the material together. A close picket fence can be made, using flexible wire for weaving in the pickets. In Japan and China bamboo fences are seen everywhere. In these countries it is a common practice to use the brush of the bamboo (that is, the tops with branches and branchlets attached) for close-woven fences. For the stringers bamboo rods are often used.

Trellises.—Many forms of trellises for use around the farm and home may be made of this light material. Trellises of all kinds for use around the dwelling house or other buildings, also wigwam

A 6-YEAR-OLD GROVE OF THE EDIBLE BAMBOO

This grove of bamboos (*Phyllostachys edulis*) was planted by Rufus Fant near Anderson, S. C. Note the graceful habit of the culms, with short internodes near the base. (Photographed by David Fairchild)

YOUNG EDIBLE SHOOTS OF PHYLLOSTACHYS EDULIS

On the left are two shoots stripped of their hairy sheaths and ready for slicing, preparatory to cooking. The shoots on the right are clothed in protecting hairy sheaths

FIG. 1.—BAMBOS TULDA AT THE BROOKSVILLE PLANT INTRODUCTION GARDEN

These bamboos, 13 to 14 feet high, have been grown two years from seed, but were killed back to the ground at the end of the first year. Note the luxuriant foliage. (Photographed by David Fairchild)

FIG. 2.—BAMBOS TULDA, SHOWING CLUMP GROWTH

No runners are produced and new culms are found close to the old ones. A new shoot is developing at the extreme right of the clump. Brooksville, Fla. (Photographed by R. N. Jones)

BAMBOS VULGARIS

A fine quick-growing clump bamboo. This stately clump is nearly 40 feet high and is probably 10 years old

trellises for summerhouses, can be quickly erected and taken down. Moonvines, morning-glories, and other climbers quickly make of these structures delightful shady retreats. Heavy poles 1 to 2 inches in diameter can be used for grape trellises and the training of bush fruits, including blackberries and raspberries. Such trellises may be put together by lashing with ordinary cheap bale wire, usually found as a more or less waste product around farms. A single-pole trellis has been found an excellent support for tomato plants. Short pieces of bamboo 2½ feet long are driven in the ground along the rows of tomato plants; a horizontal pole 10 to 15 feet long is then lashed to the top of the uprights. The tomato plants are tied to the horizontal poles.

Bean poles, pea stakes, and stakes for flowers and young trees.—Bamboos are admirable for all such uses. They are clean, hard, and rigid and may be used for several years if taken up in the fall and protected from the weather. For peas, beans, and plants of this nature the bamboo with branches left on makes the best supports.

Fish poles and fruit poles.—In nearly every neighborhood there is a local demand for good fishing poles. The timber bamboo (*Phyllostachys bambusoides*) furnishes excellent material of this kind. The grove at Brooksville, Fla., has been a sort of Mecca for the farmers of the whole county. Good fishing poles will readily sell for 25 to 50 cents each and would prove a source of considerable revenue to the boy having several hundred of them each year. On the Pacific coast many thousands of bamboo poles are annually imported for use in gathering crops, principally prunes and almonds. Poles about 10 feet long are used for knocking fruit or nuts from the branches of the trees.

Hay-curing racks.—In many parts of the Southern States, where cowpeas, soybeans, and similar coarse hay crops are grown, it is often difficult to cure the material during the rainy season. If the crops are allowed to lie on the ground and are handled like ordinary grass hay many of the leaves are lost, and much of the value of the crop goes with them. Moreover, the constant wetting leaches valuable food material out of the hay. A bamboo pole 7 or 8 feet long with a crosspiece about 3 feet long lashed 2 feet from the bottom makes a good frame for a curing rack for coarse hay. A hole is made in the ground with a crowbar, and the pole is put in it to the depth of about a foot. This leaves the crossbar about 1 foot from the ground. The hay while still green and fresh and only slightly wilted is then built into small stacks around these poles, after the fashion of handling peanut hay. No further attention need be given the hay until it is ready to store in the barn, which will be in two or three weeks, depending on the weather. It is only necessary then to pull the pole from the ground, tip over the stack, and the rack readily slips out. The entire small stack can then be forked on to the wagon by two men working from opposite sides. Practically all the leaves are thus saved, and, besides, the hay is usually cured a beautiful green color, quite unlike that which has been bleached by many rains.

Another type of hay-curing rack is suggested by David Bisset, of the Office of Foreign Seed and Plant Introduction, who has had

considerable experience with bamboo cultivation at Brooksville, Fla. Three bamboo poles 7 or 8 feet long are tied together at the top with binder twine. The free ends are then spread out to make a tripod. When set up, the poles at the base can be spread about a yard apart, and if necessary the ends can be pushed into the ground. Branches 6 to 8 inches long are left on the poles. The advantages of this kind of rack, according to Mr. Bisset, are: (1) The air space at the bottom permits quicker curing; (2) the hay can be easily placed on the rack as the short branches catch and hold it; and (3) the rack can be folded up and stored for future use.

Tool handles, clothes-drying poles, and clothesline props.—Well-ripened bamboo poles of the hardwood type, like Phyllostachys, make good handles for rakes and other tools where there is not much downward stress. They also make good clothes-drying poles when the joints are properly smoothed. For props they are excellent.

Water-carrying pipes.—It is frequently desirable on the farm to conduct water considerable distances from a well or spring for the purpose of watering plants or livestock. Some preliminary tests made at Brooksville indicate that bamboo poles may be used for this purpose. In many parts of the Orient pieces of split bamboos are used for carrying water, but there the culms are much larger than those which can be grown in the United States. The department's tests were made with well-ripened poles of uniform size, 10 feet long and approximately 2 inches in diameter. The cross walls which occur at each node, or joint, were easily punched out with an iron rod sharpened at one end. Some difficulty was experienced in making water-tight joints, but this difficulty was finally overcome in a very simple way by using pieces of rubber bicycle inner tubes about 3 inches long. The tubing was slipped over the end of one joint of bamboo, and the other joint was then forced into the free end of the tube. The ends of the two pieces of bamboo were thus brought close together and held there by the piece of rubber tube. Heavy tire tape was then wrapped around the joints, and finally the whole was painted with thick asphalt. This made a flexible waterproof connection. Such a water-carrying system if buried underground lasts two or three years.

Miscellaneous uses on the farm.—Many miscellaneous uses for bamboo will be found on the farm and in the farm home. Mention of a few of these will suggest methods and practices of utilization: Chicken coops, chicken yards, spray rods for orchard spraying, toolracks, bookracks, portière rods, poles for rugs, carpet beaters, and reinforced cement posts. (Pl. IX, figs. 1 and 2.)

At a place like the Brooksville garden, where the needs for handy appliances are much greater than on any farm, the bamboo groves have been a constant means of supplying many useful conveniences.

In this connection it may be well to call attention to a small grove planted by Mrs. C. J. Edwards at Abbeyville, La., about 15 years ago. Mrs. Edwards secured her plants (*Phyllostachys edulis*) from the United States Department of Agriculture and put them out in her back yard. The grove now covers a space about 100 by 100 feet and contains upwards of 1,000 canes 40 to 50 feet in height and 3 to 16 inches in circumference. A year or two ago the owner cut 170 large canes, or poles, from the grove and sold them for $1,000.

They were used in the construction of a tea house. This grove should yield from 200 to 400 good canes each year. This is of course an exceptional case, but it shows that opportunities for profit are not lacking.

The small stake bamboo will prove not only a valuable plant for many purposes already described but may be found useful as a forage crop. It has been grown experimentally in Georgia and other States for this purpose. So there would appear to be many good and sufficient reasons for the development of several hundred thousand of what might be called acre home groves, especially on our southern farms. The cost of developing such a grove would be small, and its care would not be a burden.

Just a precautionary word or two should be said regarding the tendency of these plants to spread when once they get a foothold. Some care is required to keep them within bounds, but as a rule this can be done by the timely digging of any offshoots that may appear beyond the border of the planted area.

Further details regarding these matters will be given in considering the propagation and culture of bamboos.

BAMBOOS AND POULTRY

During the past 15 to 18 years there has developed in the Southern States a commendable line of work involving the organization of boys' and girls' clubs for the growing of poultry and pigs and for other purposes. Bamboos and poultry make a happy combination, and their use in this connection is strongly recommended. A grove not only furnishes excellent protection from hawks and other birds of prey but provides shelter from the hot suns of summer and the chilling winds of the colder months. (Pl. IX, fig. 1.) As already pointed out, coops, roosting places, and poultry houses can be provided from the surplus canes. The droppings furnish an excellent fertilizer for the bamboo plants. At Brooksville, Fla., one end of a large block of giant timber bamboos has been used as a chicken run for a number of years. These plants are now the strongest and best of the block, many of them being 35 feet high. It would be practicable to cut 30 to 40 fine canes from each square rod of this block and still leave enough for continued growth and reproduction. Bamboos can therefore be recommended as a feature of boys' club work, and especially in connection with the growing of poultry.

County agents and others in the Southern States identified with boys' club work may find it well worth while to call special attention to the possibilities of bamboo growing as a part of their demonstration activities.

BAMBOOS AND RURAL SCHOOL GROUNDS

Rural school grounds are often bare spots, and within certain limits this bareness is necessary from the very nature of the uses to which the grounds are subjected. For actual utilization purposes as well as for æsthetic reasons some bamboos should find a place on rural school grounds. The larger forms, such as the giant timber bamboo, will give a very grateful shade at all seasons and will also prove a protection against wind and storms. The smaller kinds,

such as the stake bamboo, will prove excellent screens for unsightly outbuildings, bare walls, and for surrounding the borders of school grounds. In schools where manual training is taught the bamboos would furnish most excellent material for many kinds of handicraft activities. (Pl. X, figs. 1 and 2.) For the first years of the life of the bamboos it will be necessary to fence them, in order to protect the young shoots from being broken off. Protection will also have to be given when the shoots are coming through in spring.

WINDBREAKS, HEDGES, AND SCREENS

It is often desirable in farm, orchard, and grove work to protect buildings or certain trees and other plants from winds that may do injury. Bamboos lend themselves well to this use, particularly as windbreaks and tall hedges. Some of the ornamental bamboos serve well for the purposes mentioned. In the warmer sections of the South, and especially all that part of Florida south of Gainesville, as well as part of southern Louisiana, the hardy forms of *Bambos vulgaris* and *B. tulda* will be found most suitable for the purposes here discussed. If one has canals, ditches, or watercourses on the farm, bamboos will thrive in such places.

BAMBOOS AS FORAGE AND GRAZING CROPS

Some of the smaller thicket-producing bamboos, like *Phyllostachys nevinii*, may prove useful in many parts of the South for winter grazing. These plants produce a large quantity of leafy forage, and grazing, if not too heavy, does not seem to hurt them. Some preliminary testing has been done by C. S. Tait at Brunswick, Ga. Mr. Tait is growing the stake bamboo, already described, and finds that cattle eat it readily. A few small plants were sent him in 1915, and without any special care these had spread to such an extent that in 1919 they covered a space 40 by 45 feet. There are many thousand acres of more or less waste lands in the South where this bamboo would grow and where it would most likely prove a valuable addition to the limited forage of the region. It should prove particularly useful for winter grazing, furnishing more fodder than the native wild cane.

BAMBOOS FOR EDIBLE PURPOSES

Young bamboo shoots constitute an important article of diet in oriental countries, particularly China and Japan. Considerable quantities of the canned shoots are imported into this country, chiefly for the use of oriental residents. From the records at hand it appears that the annual importation of such material is nearly 450 tons. There are a number of bamboos that supply edible shoots, but the only important one the department has succeeded in establishing in the United States is *Phyllostachys edulis*, already described (Pl. VI). Shoots of the large timber bamboo (*P. bambusoides*) when properly handled may be served as an edible dish. This bamboo, of which fine specimens are to be found in the Barbour Lathrop grove, near Savannah, Ga., has furnished material on several occasions for banquets and other functions.

It is only after a bamboo grove has become very well established and is sending up culms 20 to 30 feet high that shoots suitable for

food are available. These are allowed to reach a height of 6 to 10 inches, when they are cut off below the ground, like asparagus. The usual practice is to dig down and cut off the young shoots at the rhizome which bears them. (Pl. VI.)

Bamboo shoots are known to most persons who are familiar with the chop-suey dishes served in Chinese restaurants, but methods of utilizing them in American cookery have not yet been thoroughly worked out. The suggestions given below are offered, however, as the result of some preliminary cooking experiments.

Remove sheaths and cut the shoots into pieces, crosswise, lengthwise, or diagonally, or into squares or oblong pieces. Boil in a small quantity of salted water (adding more water as needed) 30 minutes or more until fairly tender. Shoots of suitable age when properly cooked are always firm and somewhat crisp rather than soft. Pieces from the base of a shoot may require more cooking than those from nearer the tip, but they generally have a better flavor.

Bamboo shoots may be served with plain butter, butter sauce, or cream sauce. The flavor somewhat resembles very young field corn, with a slight bitterness, which is made entirely unobjectionable by the addition of the butter or other dressing.

When cut into suitable small pieces the cooked shoots may also make an acceptable addition to a salad.

The following directions for cooking are taken from Fairchild's publication (*4*, p. 25):

1. *Bamboo sprouts with cream sauce.*—These sprouts are cut when about a foot above the ground, by digging down to the rhizomes which bear them. After being gathered the outside sheaths are removed, and the shoots are soaked for half an hour in cold water. They are then cut in thin slices, about 3 inches long by 1 inch square, and thrown into boiling water containing a small teaspoonful of salt and are boiled from an hour to an hour and a half, or until tender. The pieces are then drained and a white sauce is poured over them, which is made in the following way: To a half pint of cream or milk add a teaspoonful of butter; season with salt and black pepper. Allow this to boil up and serve at once. If desired, this sauce may be thickened with flour.

2. *Bamboo shoots in butter.*—Slice and cook, as in the previous recipe, until tender. Into a saucepan put three tablespoonfuls of butter, seasoned with pepper, salt, and a little chopped parsley. When heated, put in the bamboo. Shake and turn until the mixture boils; then lay the bamboo on a hot platter, pour the butter over it, and serve at once.

3. *Bamboo shoots, Japanese style.*—Slice and cook the bamboo until tender, as in recipe No. 1; then put into a sauce made as follows: Take one coffee cup full of soy sauce (this is the basis of Worcestershire sauce and obtained only at Chinese or Japanese grocers or at some of the largest groceries in our large cities), one-fourth cupful of water, one heaping teaspoonful of sugar; let boil for half an hour in this sauce and serve.

COMMERCIAL USES

The commercial uses of bamboos, as distinguished from domestic uses, involve their planting and production on a more or less extensive scale so as to secure materials in quantity for manufacturing purposes for certain of the arts and possibly for food.

The manufacture of fancy fly rods or split-bamboo fishing rods, for example, involves the use of large quantities of special bamboo material now imported from the Orient, chiefly from India. It is generally understood that the most desirable material for making these choice fly rods is derived from *Bambos tulda*, commonly referred to in the trade as the Calcutta bamboo. Reliable figures are not available as to the quantity and value of these materials imported, nor are data at hand as to the value of the finished fly rods.

It has been stated to be several millions of dollars a year, but this is probably an overestimate. It is evident that there is an industry here of considerable importance, based wholly on raw material secured from abroad.

Whether any or all of this material can be grown in this country needs to be determined by careful experimental tests extending over several years. We must not only learn how and where to grow the bamboo but we must be able to impart to others practical knowledge as to how to cultivate it, cut it, cure it, and put it in a condition equal to or better than the imported product and at a price that will pay for our own labor and compete with that of the Orient. This is a very large bill of requirements, but in matters of this kind it is well to present the actual facts as we see them, and then the real problems which have to be met will be better understood. In new crop problems all limiting factors must be kept clearly in mind.

One of the greatest difficulties with bamboos is quantity production on a scale sufficient to warrant commercial firms in becoming interested. Men who have been in business for years and who have located a thoroughly reliable and dependable source of raw material suitable for their purpose are not going to change to some other source without good reason. The reasons that would prompt them to change would be, first, superiority of the domestic product, second, lower price, and, third and probably most important of all, assurance of a continued supply. It will be many years before this country is in a position to meet even the small demands of manufacturers or others using bamboo in their work. For this reason the domestic uses of the plants have been stressed as a first step leading to production in quantity. The domestic production, if carried out along the lines suggested, it is believed will provide a source of plants for propagating purposes that can not well be met in any other way.

With these more or less fundamental and governing economic facts in mind, we may turn to other commercial uses of the bamboo which would seem to warrant study and experimentation.

Reference has already been made to fancy fly rods made of split bamboo. Several million ordinary bamboos are imported for fishing rods. These come mostly from Japan and China. They are sold throughout the United States and undoubtedly could be grown here, but we need to learn how to cut, cure, and handle them. Whether with the high cost of labor here this country could compete with the Orient in production on a commercial scale remains to be determined.

Bamboo plant stakes for florists' and nurserymen's use are imported by the million. Three kinds of stakes are used by florists in this country: (1) Natural Japanese canes, (2) colored Japanese canes, and (3) southern canes (uncolored).

The natural canes are those grown in Japan and shipped into this country without being artificially dyed. They vary in length from 2 to 10 feet and in girth from the size of a lead pencil to about three-fourths of an inch.

The colored canes are those which are grown in Japan, artificially dyed in that country, and then shipped here. Most of these canes are dyed green. The coloring process is not known.

Southern canes are cut in this country from the native cane which is so common in the Southern States. The scientific name of this bamboo is *Arundinaria tecta*. These canes as they appear on the market are from 3 to 8 feet in length and little larger than a lead pencil in girth. Six-foot canes sell wholesale for about $10 per 1,000 and 10-foot stakes for $27.50. Southern-cane stakes 7 to 9 feet long sell for about $14 per 1,000. The plant stakes are easily grown, the stake bamboo (*Phyllostachys nevinii*) being one of the best for this purpose. The production of plant stakes appears to be one of the small commercial enterprises that might well be undertaken in this country, as it could be carried on in places and in a way that would not involve much labor, a sort of side line, as it were, in connection with the use of the same plant as a forage crop. Then, there are large quantities of bamboo material imported simply under the name of poles. These poles are cheap and it is believed are harvested mostly from the timber bamboo (*Phyllostachys bambusoides*).

From our experience with the bamboo there would seem little doubt that it can be grown here so as to meet the demand for most of the purposes above indicated, provided the competition of the Orient in the matter of cost can be met.

BAMBOOS FOR TIMBER

The lightness and strength of the large timber bamboo make it very valuable in many kinds of construction work. Lack of knowledge as to how to handle such material is one of the drawbacks here. A Japanese or Chinese craftsman will take this wood and do many things with it that would be entirely beyond our own carpenters. Note the scaffolding where large construction work is under way in any Japanese city. It is made entirely of bamboo poles lashed together in such fashion that it is quickly put up, taken down, and used over and over again. An American would find difficulty in moving on one of these scaffolds, but the Japanese workman clings to the round, smooth poles with his bare feet, like a chicken on a roost. Many of the cozy homes of Japan are built almost entirely of timber bamboos. Unsplit poles are used for supporting posts, rafters, and beams; split poles are employed for siding and many other purposes.

The Japanese, as well as other peoples of these eastern countries, use the thin-walled bamboos split and woven into a kind of coarse matting for both exterior and interior construction. In the Philippines this material is called "sawale," and according to a bulletin (*1*) issued by the Philippine Department of Agriculture it has value for the construction of light bungalows even in temperate climates. Quoting from the bulletin:

> It is also very attractive as an interior finish in strong-material houses. Sawale is of particular advantage in the construction of large temporary buildings. In Manila there is held an annual carnival, in which very imposing structures are constructed rapidly and cheaply with the aid of this material. When the Philippine National Guard was organized, all the barracks were constructed very quickly on account of the use of sawale. In the entire Philippine exhibits at the Panama-Pacific International Exposition at San Francisco, Calif., various weaves and classes of sawale were used extensively in the

installation of the different booths. This proved so attractive and demonstrated so clearly its use that the people visiting the exposition ordered material of the heavier weave for summer cottages in California.

Light bridges, bridge sills, fence posts, and temporary telegraph and telephone poles are other objects for which this large bamboo may be used.

In connection with temporary Army engineering work, especially in the Philippines, bamboo has been found useful in the hasty construction of bridges and trestles. Army engineers point out the advantages of bamboo for such use as follows:

It is very light in proportion to its size and strength and easily cut and handled. Its annular cross section adds greatly to its strength, both columnar and transverse. It occurs in sizes convenient for use.

The disadvantages of bamboo for high bridges, etc., are as follows:

It splits and crushes easily and can not be secured by either bolts or spikes. Lashings will not hold securely if any great strain is brought upon them. Bamboo can not be notched or dapped without seriously diminishing its strength. It is difficult to cut down and drag out of the clumps in which it grows and can not be obtained in large sizes.

Despite these objections bamboo for temporary bridges, trestles, etc., has proved very useful.

Bamboo is successfully used in the manufacture of baskets, blinds, and certain types of furniture. Its use in furniture making would doubtless require a good many modifications to adapt it to American practices. A number of years ago the late Frank N. Meyer, Agricultural Explorer for the Office of Foreign Seed and Plant Introduction, discovered a quite important bamboo manufactory in the Russian Caucasus. He was traveling near Chavka, where the climate is much like that of some of the Gulf States, particularly northern Florida. The summers are long and hot and more or less humid, the autumns long and warm and dry, and the winters very short and rather wet. Mr. Meyer found four principal bamboos of the large timber types being grown and used in the manufacture of furniture of various kinds, including plain chairs, rocking-chairs, settees, tables, and stands. This furniture is popular and sells at a good price.

Mr. Meyer noted in connection with this utilization of the bamboo that the material had to be steamed to keep it from cracking. Bamboo canes, when cut, are placed in iron cylinders 1½ to 2 feet in diameter. The canes are pushed into these cylinders until they are full; then the doors are closed with bolts and steam is applied at high pressure for about an hour. When the canes have been in the cylinders sufficiently long, they are taken out while yet warm and wiped with wet rags. They are then allowed to cool by placing them on racks in airy barns where the wind has free access and where the sun does not shine. Steaming prevents cracking. To bend the smaller pieces of bamboo for furniture and decorative fence making they are first filled with dry sand to the joint to be bent; then a flame from a plumber's torch is applied. The bamboo is slowly bent while it is being heated. When this is done carefully few pieces break under the process.

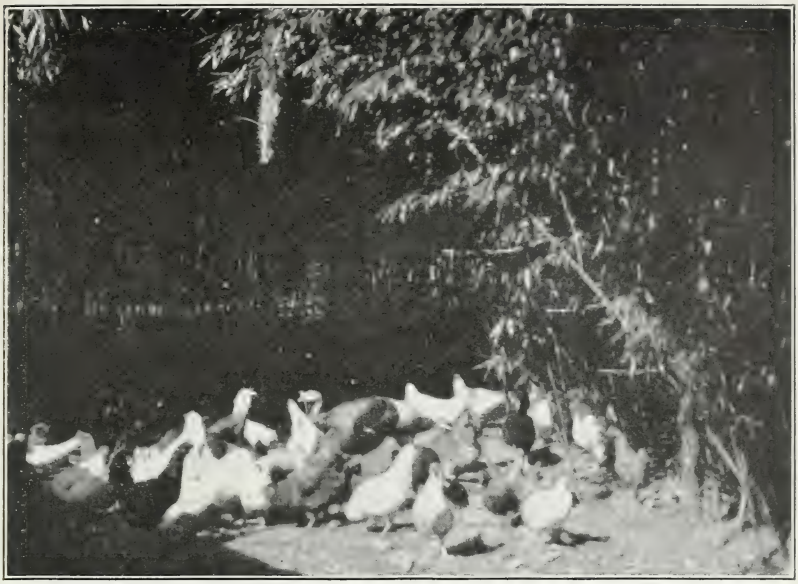


FIG. 1.—BAMBOOS AS A SHELTER AND PROTECTION FOR CHICKENS AND TURKEYS

FIG. 2.—SPLIT BAMBOOS USED FOR REINFORCING CONCRETE POSTS

FIG. 1.—BAMBOOS USED FOR SCREENING AN UNSIGHTLY WALL

FIG. 2.—BAMBOOS FOR A PLAYGROUND

A bamboo grove makes a very satisfactory playground for children, being cool in summer and sheltered in winter

FIG. 1.—BAMBOOS PROPAGATED BY THE CLUMP METHOD

A lifted clump containing three stems, a number of pushing eyes or young shoots, and the connecting or supporting rhizome. The soil has been washed off. In shipping, this clump could be divided into two good plants

FIG. 2.—THREE BAMBOO CLUMPS CONTAINING SEVERAL STEMS AND ROOTS WITH SOIL ATTACHED READY FOR TRANSPLANTING

FIG. 1.—A BUNDLE OF 100 BAMBOO RHIZOMES SUITABLE FOR PROPAGATION

These rhizomes have been cleaned and when ready for packing weigh about 2¾ pounds

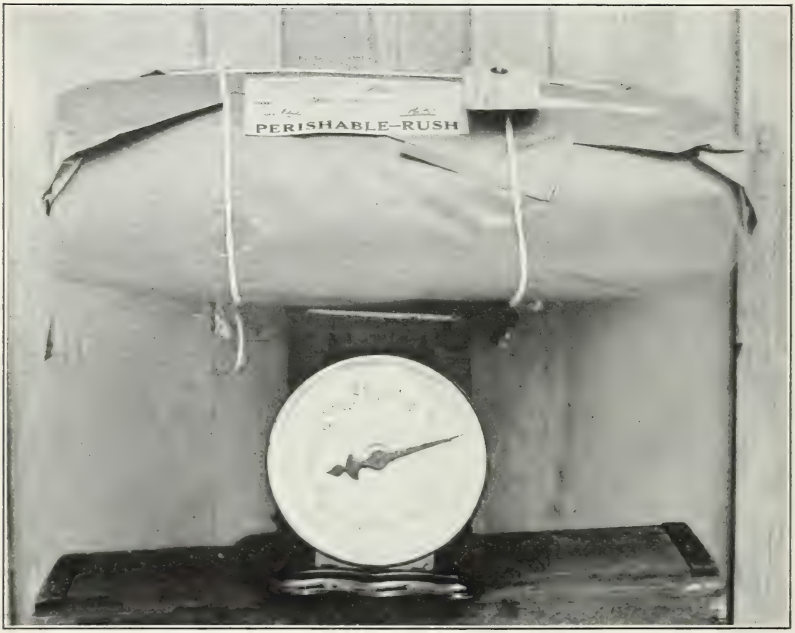


FIG. 2.—A BUNDLE OF BAMBOO RHIZOMES PACKED IN WET BURLAP READY FOR SHIPMENT

These rhizomes, weighing 4¾ pounds, were shipped from the Brooksville garden to Washington, D. C., and 50 good plants were obtained from them

BAMBOOS AS PAPER-MAKING MATERIAL

Considerable attention has been given to the manufacture of paper from several species of bamboo. The more important lines of this work have been carried on in India and the Philippines, where large quantities of the tropical forms are available. With the exception of *Bambos tulda* few of the forms which can be grown in this country would be entirely suitable for paper making, as they could not yet compete with more easily produced material. Paper making, to be economical, involves large initial outlays for equipment and chemicals, the recovery of these chemicals, and the maintaining of expensive machinery. In other words, it is an industry that can not be undertaken on a small scale. A large well-equipped factory is essential to success.

Bambos tulda should be especially mentioned as having potential value for paper making. In the first place, it may be propagated from seeds, which is a great advantage where quantity production is required in a comparatively short time. The seedlings are easily handled and lend themselves readily to field transplanting and field culture. The plants grow rapidly if on good strong soil where frosts and freezes are not likely to interfere. This bamboo is too tender for the climate at the Brooksville garden. At points south of Brooksville, notably along the Gulf coast, it should do very well and should yield from 40 to 50 tons of paper-making material a year per acre after about the fourth or fifth year. This is based on taking out about one-third of the culms each year. For by-products this bamboo could also be utilized in the manufacture of split fishing rods, phonograph needles, and brushes and brooms of many kinds.

MINOR USES

Among the minor commercial uses of the bamboo that might have consideration may be mentioned the manufacture of crates and barrel hoops and the construction of porch swings, etc. As a prerequisite to the encouragement or conduct of any industry, however, an adequate supply of raw material is absolutely necessary. As an illustration of this point may be cited the experience of a few years ago when, through the efforts of the Office of Foreign Seed and Plant Introduction, certain firms became interested in obtaining bamboo material for use in manufacturing phonograph needles. One firm stated it could use 10,000 to 15,000 poles a year, each pole to be 15 feet long and from 2 to 3 inches in diameter. Samples of *Bambos tulda* from the Canal Zone were sent, and these samples were so satisfactory that the firm was ready to place an order. It was then necessary to say that there were no culms available in the Canal Zone. Similar tests were made by the same firm on the Savannah bamboos, which at that time had not come into the possession of the department. This bamboo also was found to furnish good material for phonograph needles, but here again there was no adequate supply of the material. This factory would have exhausted the Savannah stock in a week or two, a stock from a grove that had taken nearly 30 years to grow.

In closing this discussion of the commercial uses of the bamboo, it is hoped that the point has been made plain that production of the

raw material in workable, usable quantities must always precede manufacturing exploitation. This is tantamount to saying that for a good many years our major efforts must be in the direction of encouraging the development of plantations of the kinds of bamboos likely to be useful for manufacturing purposes. Even this line of work is not without serious difficulties, chiefly because the bamboo is not unlike forest trees as a crop. Americans have not the patience of those in older countries who are often content to plant not for the present but for the benefit of future generations.

PROPAGATION AND CULTURE

Bamboos are both easy and difficult to propagate. When all conditions are right the plants are readily increased; when conditions are not favorable no amount of effort gives success.

There are three principal methods of propagating bamboos: (1) By seeds, (2) by division, or splitting up the clumps, and (3) by cutting off and planting the rhizomes, or underground stems. The rareness of the seeds and the difficulties attending propagation by division explain in part why the bamboos have spread so slowly over the earth. The divided plants will not stand long-distance shipment unless great precautions are taken. This is one reason why the development of plantations in the United States must necessarily be slow. In the Orient, and particularly in China and Japan, the clumps of plants most suitable for the establishment of new groves never need to be transported very far. It is usually a matter of neighborhood arrangement and almost wholly of man labor. This makes the plants very cheap, as the major cost involved is that of lifting and moving. On the other hand, the shipment of a 10 or 15 pound clump containing two or three good plants for a hundred or a thousand miles in this country makes the cost nearly prohibitive.

Then, again, there is always involved the danger of shipping clumps of plants containing soil around the roots. Some of our worst crop pests have been spread in this way. This is why the Federal Horticultural Board no longer permits the entry of so-called "balled" plants, with soil on the roots. The days, therefore, when 500 pounds or 1,000 pounds of bamboo clumps could be imported from any foreign country are past. All these matters and many more make it necessary to attack the problem of bamboo propagation along lines more or less new. As yet a start in this direction has hardly been made. It is hoped that enough has been done, however, to point the way for others who may wish to attack the problem.

The bamboos just described, with the exception of *Bambos tulda*, may all be propagated by division; that is, the parent, usually consisting of one or more plants in a clump, may be divided in such fashion that each piece will consist of a good rhizome containing one or more buds or eyes, a supply of roots, and, where practicable, a small portion of the culm, or stem. In order that this matter may be understood clearly, let us examine the underground parts of the creeping bamboos and point out the essentials in propagation. (Pl. XI, figs. 1 and 2.)

If a young clump of any of the Phyllostachys bamboos is examined in early summer young plants will be found coming up on the

outer edges of the clump. In digging down, these young plants are found to be attached to rhizomes, or underground stems, which go back to older mother plants. Besides the plant there will be found on the rhizome numerous eyes or dormant shoots. If the stems, or culms, together with a piece of the supporting rhizome are lifted carefully with a ball of soil the whole will make a good young clump for propagating purposes. (Pl. XI, figs. 1 and 2.) If it were only a matter of moving this clump a short distance, the whole thing could be lifted with the soil attached and set in a place properly prepared for it. But in order to ship the plant any distance, it must be further divided; that is, the connecting rhizomes must be cut, leaving a stem attached to a piece of rhizome, one or more good eyes or buds, and a supply of roots.

A divided plant, such as described, if properly cared for will make a fair growth the first year and will usually send out new rhizomes from which several plants will develop. This is the most satisfactory type of plant to use for propagating purposes, for if the rhizomes are strong, the eyes sound and full of life, and the stems and roots satisfactory, growth will start promptly and be maintained steadily if soil and other conditions are right. If one has a nursery and is propagating for himself this is the method to follow, for the question of transportation does not enter into the problem. Of course, there are many other points to be observed; these will be mentioned later. It should be stated that in divisional propagation which involves old stems and often leaves, serious diseases and insects may be carried over, especially the Japanese mite, several scale insects, and the brown or powdery rust.

The other method of increasing the plants, which may be called rhizome propagation, is, as the name indicates, the utilization of the rhizomes only, with one or more good eyes and a few roots attached. These parts are wholly under ground, and their removal and handling do not involve balls of soil. In Plate XI, Figure 1, are shown three such rhizomes, each about 1 foot long.

Finally may be mentioned the method of propagation by seeds. *Bambos tulda* is the only one included in our list of which seeds may be obtained. The securing of seeds and the methods to be followed in growing them will be discussed later.

In order that the matter of propagation may be discussed intelligently, an endeavor will be made to trace, step by step, the procedure to be followed in the development of farm-home groves and groves and plantings for other than commercial uses. Where it is practicable to get good, clean, healthy divided plants, it will be best to do so in making a start. These should be obtained in early spring, either March or April. For the first year the plants should be set in a nursery, where they can be given better care and attention than in the open field. Good, well-selected garden soil furnishes the best conditions for the nursery work. By garden soil is meant a rich loam that will produce good crops of potatoes, string beans, or sugar corn. Set the plants in rows 5 or 6 feet apart and about 2 feet apart in the row. It is very important the first year if dry weather comes that the plants be regularly watered. They must be kept growing steadily and continuously. If well cared for, new shoots will soon appear and new rhizomes develop. By fall the mother plant will

not only be much stronger, but there will be several smaller plants and a number of rhizomes with buds or undeveloped shoots upon them. The next spring, preferably between the middle of March and the middle of April, the clump may be lifted and divided. The strongest plants may now be set where the grove is to be established, and the weak ones, together with such rhizomes as have become available, may again be planted in the nursery in the manner already described.

For the permanent grove it is essential that fairly good, well-drained soil be selected. Bamboos are quite particular in this respect. It is a mistake to suppose that they can be grown successfully on poor, rocky, gravelly, or badly drained soils. Fertile cotton, corn, or sweet-potato land should grow good bamboos. They need much water, but they do not want to get it from an overwet soil.

In putting out the plants for the grove they should be set about 8 by 8 feet or 10 by 10 feet apart. This will require 680 plants per acre if set 8 by 8 feet and 435 plants if set 10 by 10 feet. Before planting, the ground should be plowed and harrowed about the same as for cotton or corn. Set the plants 4 to 6 inches deep, cover carefully, and firm the soil well around each plant. If dry, the plants should be watered. All through the first season water should be given in the event of protracted dry weather.

The first two or three years are critical ones for the grove, and much patience and perseverance will be required. It must be largely a matter of hand weeding and cultivation. The young rhizomes will be extending in all directions, and to put a cultivator and mule or horse into such a place would result in wholesale destruction of the very things it is vital to save. For the Orient this type of hand labor means little, for it is everywhere abundant and cheap. Once the bamboos are large enough and strong enough to take possession of the ground they can fight their own battles, so that weeds and especially crabgrass will have little chance.

To return now to the nursery work. If one desires to continue producing young plants, either for home planting or for sale, the best plan is to lift all the plants every second year and start a new nursery. This will give strong plants for sale or for permanent plantings and many small ones, together with quantities of good rhizomes, to go on with the propagating work. By this procedure one always has quantities of young rhizomes for propagation, and this is very important. If rhizomes from old plantings must be depended on, one never knows their age, with the result that many fail to grow. They look all right, have good eyes, but are sterile. Rhizomes, therefore, should not be more than 2 years old. This is highly important.

There are many more rhizomes than plants produced, and for this reason the fact that they may be cheaply and easily transported long distances and are as a rule free from dangerous enemies makes them highly desirable as propagating material. (Pl. XII, figs. 1 and 2.)

While a small clump containing only two or three plants may weigh 5 to 8 pounds, a hundred properly selected rhizomes weigh less than half as much. As already pointed out, the rhizomes are clean or may be easily made so, which is a very important point in their favor. A hundred good rhizomes, if properly handled, should give at least 50 good plants.

In handling rhizomes so as to secure the largest number of good plants from them, either one of two plans may be followed. First, a good piece of garden soil may be selected, and after thoroughly preparing the land to a depth of 8 or 10 inches a trench may be dug 3½ to 4 inches deep. The trench must be sufficiently wide to permit placing the rhizomes on the bottom, side by side and about 2 inches apart. This means that the trench must be from 10 to 12 inches wide and 3½ to 4 inches deep. After placing the rhizomes in the trench, they are covered and the soil carefully firmed with the hands. Rough treatment, such as tramping or rolling, is to be avoided, as this sort of procedure is likely to break off or injure the eyes. If the weather is dry the rhizomes should be watered, and at no time during the growing season should they be allowed to dry out. It is important to understand this, for during the first two or three months of the life of these cut-off rhizomes the young shoots draw mainly on the stored food in the rhizomes for sustenance. The object is to take every care to see that the rhizomes produce feeding roots as quickly as possible.

As an illustration of the method of propagation by rhizomes, an experiment at Brooksville, Fla., may be cited. This work was done at the suggestion of the writer by Robert Jones, who was at the time, 1919, in charge of the bamboo project. Two pieces of ground were selected for the work, one at the garden proper and the other a better drained piece about half a mile away. The rhizomes were lifted in February and March, but owing to the fact that they were taken from old groves it was not practicable to tell their age. It was also necessary to dip the rhizomes in water containing soap and nicotine extract, as this was part of an experiment in mite control. Altogether, something more than 82,000 rhizomes of four or five different bamboos were handled. After treatment in water the rhizomes were planted in trenches, as described. It turned out that the season was dry at times, and water was not available for constant use. Notwithstanding this drawback and others about 28,000 plants were produced, sufficient for planting about 20 acres of permanent grove. The cost of producing the plants under these rather unusual conditions was about 2 cents each.

The second method of handling rhizomes is called the frame method, for the reason that the plants are grown in frames much like ordinary coldframes used for many gardening operations. The frame method is preferred to that of the field, for it is more in keeping with the art and practices of a good gardener. Here production is on an intensive scale. Every inch of ground must be made to pay, and this brings out the best skill of the grower. Frames are made 6 feet wide and as long as desired. Boards 1 foot wide and 1 inch thick make good sides and ends with rough 2 by 3 or 2 by 4 inch posts for support. The soil in the frame should be a rich mellow loam, spaded and fined to a depth of at least a foot.

When all is ready a trench 1 foot wide and 4 inches deep is dug across the end of the frame, the soil being placed outside. Into the trench the rhizomes are laid side by side and as close as possible. When the first trench is filled with rhizomes, a second one is dug 6 inches distant, and the soil from the second trench is used for covering the rhizomes in the first. Proceed in this way until the whole frame is filled. The last trench may then be filled with the

soil taken from the first one. The soil must be carefully worked and firmed around the rhizomes with the hands, and when all is finished a good watering should be given. A frame 6 feet wide and 50 feet long will hold from 1,800 to 2,000 rhizomes of average size. With good care this frame should contain at least 1,200 plants by the following fall. The plants can stand in the frame all winter, and if there is considerable frost a little protection in the shape of straw or fine brush may be given. Between March 15 and April 15 the plants may be lifted, divided, and set in nursery rows in the field, as already described.

It is necessary to emphasize one point, and that is the time for lifting and dividing the plants and taking off the rhizomes. To get the best results this must be done in spring, just before the buds begin to push. It is at this season that very vital biological changes take place in the food supply of the plant, and especially in the reserve food supplies. If rhizomes are removed from the parent plant before these changes start there will be no growth or else a very feeble one, resulting in the development of a few sickly shoots, which soon die. On the other hand, if rhizomes are taken too late—that is, after new shoots have started and new branches and leaves are appearing—failure is likely to result. It is repeated, therefore, that it is of vital importance to do the dividing and take the rhizomes just before growth starts, which, for the group of plants now under discussion, the Phyllostachys forms, for most of the Southern States will be between March 15 and April 15.

A combination of the frame method, using rhizomes, and the field method of growing the plants for two years in a nursery will serve as a rapid means of increasing the stock of both good plants and good rhizomes for home use or for sale.

Inasmuch as the transportation of plants or clumps with soil attached is not without serious difficulties, chiefly on account of first cost and the danger of distributing crop pests, it is recommended that the rhizome method of getting a start have first consideration. This method presupposes a desire and intent on the part of the person receiving the rhizomes to give them the best of care. They can not be put away in a corner of the garden or field and left to fight weeds and drought. They must be cared for, and if this is done it is believed that success will follow. If groves are ever to be established in this country on a scale sufficient to make possible a new crop industry, some quicker method than the cumbersome, expensive, and risky one of shipping clumps of plants about the country must be adopted.

The experience of 20 years has shown that bamboo culture is extremely slow work. Really serious efforts to build up plantations would mean something along the line followed in the cooperative development of wood lots now being practiced in a number of the States or the cooperative tree planting and windbreak work of our northern Great Plains and certain of the Canadian Provinces. To establish wood lots and windbreaks, a certain amount of expert supervision in the initial stages of the work has been found necessary. Also, the need has been shown for providing suitable planting material, at least in sufficient quantity to enable those interested to get a fair start.

With regard to the propagation and general handling of the clump bamboos, it has already been pointed out that these plants are not provided with rhizomes. The clumps are readily capable of division, however, by simply cutting up the thick crowns. (Pl. XIII.) The large-growing clump bamboo is never small except in the seedling stage, and that is very rare. For this reason the divided parts are coarse, heavy, and hard to handle. Care must be exercised to see that the crown is provided with several good eyes or buds, some roots, and a portion of the old stem. The clump bamboos are strong growers and rank feeders; therefore they require rich soil. They should do well when planted around barnyards and in places where the drainage from the stock pens will reach them. Their tenderness limits their range, but wherever the temperature does not fall below 25° to 30° F. more than a few times during the winter they are safe. This does not apply to *Bambos tulda*, which is more tender. In planting the clump bamboo a good-sized hole should be dug, and the entire crown and a portion of the stem should be buried. The soil should be well firmed and the plants watered in case of dry weather.

The great hollow stems of *Bambos vulgaris* will be found very useful for many purposes around the farm. The clumps, too, offer shade and protection to stock and may be the means of hiding unsightly buildings and trash yards, more or less necessary evils on almost every farm. In Algeria and adjacent countries on the North African coast, where frost seldom occurs, the clump bamboos are planted extensively for many purposes. In some sections they are grown for firewood; also for many kinds of simple house construction, for fence posts, and in the drying up of mosquito breeding grounds.

The production of *Bambos tulda* from seeds is a comparatively simple matter. The seeds look like ordinary oats and germinate readily when sown in a warm moist soil. If desired, flats or shallow wooden boxes may be used for starting the plants. The flats may be made of cut-up soap boxes or any box 24 to 30 inches long and 18 or 20 inches wide. Cut the boxes so the flats will be 4 inches deep, and provide each flat with a strong bottom. Fill with good rich sandy loam to a depth of 2½ inches. Tamp the soil firmly with a brick or a piece of 2 by 4 inch lumber. Sow the seeds thickly, cover with an inch of good soil, tamp again, and water. The flats containing the seeds will need to be kept in a sash-covered frame or greenhouse until the seedlings are 3 or 4 inches high. The temperature should not go lower than 60° F. at night. When the young plants are 6 to 8 inches high they may be transplanted to the garden in nursery rows 2 or 3 feet apart and about a foot apart in the row.

The simplest method of growing the bamboo is to sow the seeds in a frame. This may be an ordinary coldframe 6 feet wide and as long as desired. See that the ground is rich, loose, and friable. Sow the seeds in drills 2 inches deep and 1 foot apart. Space the seeds so that the seedlings will be about 1 inch apart in the row. Cover carefully, firm the soil, and water. Glass sash will be necessary at first to protect the young plants from beating rains and winds. It will be best not to sow the seeds until settled warm weather has

arrived. The plants may be left in the frame for a year and then transplanted to the nursery or field, as desired.

Seed of *Bambos tulda* is not available in this country. It would have to be secured from abroad, and inasmuch as all such material is quarantined it would need to go before the Federal Horticultural Board at Washington and be treated before being released.

As to the care of bamboo groves after they have become established, the proper harvesting of the poles, and the manipulation of the cut material so as to make it most useful, it is impossible to speak with authority, as experience is lacking. Nor can much information along this line be obtained from any of the published data available. No one from this country with a full knowledge as to our practical needs has been able to make a sustained study of the subject. There are many fragmentary notes and comments, but these are often so conflicting and so at variance with anything within reach that they can not be of use. Nor can much help be obtained from statements of what has been accomplished by growers in the south of Europe and in the countries of North Africa. As already pointed out, we must necessarily work out our own methods. It is evident that our groves must have care. They can not be left to themselves any more than a good wood lot can be left alone and be expected to prosper.

The practices in the care of a grove will be (1) thinning, (2) fertilization, and (3) cutting.

In the matter of thinning, attention may be called to two groves, one near Savannah, the Barbour Lathrop grove, and the other at Brooksville, Fla. The first grove has been thinned, whether intentionally or not is unknown. The culms number from 36 to 48 per square rod. Bamboos of the same variety at Brooksville, although not so old, have not been thinned, with the result that the culms are seriously crowding each other and undoubtedly checking growth. Here the number of culms per square rod runs from 110 to 215. Fairchild (*4*), in speaking of this matter, says:

> For the first three years at least all the shoots that appear should be allowed to mature, but after the grove is once well established only the largest shoots should be permitted to grow, the others being cut out as soon as they appear above the ground. This thinning process throws the strength of the plants into a comparatively few large culms and gradually increases the height and strength of the forest.

Sir Ernest Satow (*13*) deals with the matter of thinning in this way:

> The plantation must be neither too thick nor too sparse. If too many stems are cut out and the spaces left are large, the sun's rays penetrate, the stems turn yellow, the pipe becomes thin, the knots become enlarged, the ground gets dry, and the fertilizing principle evaporates, so that the good canes gradually decrease in number and the plantation finally becomes thin and impoverished. It is therefore not advisable to leave in stems more than 4 years of age, but the plantation should always be left so dense that even in broad daylight it shall be pervaded by semiobscurity. The sun's rays should not penetrate; otherwise the soil will not remain constantly moist. The fallen leaves and rubbish decay and rot naturally, producing a constant supply of humus, and the canes preserve a deep-green color. In this way the plantation gradually produces a good class of canes, both stout and tall, and presents a handsome appearance.

In order to thin intelligently, some method of marking the culms is necessary. Labels fall or may be knocked off. Copper tacks

BAMBOS VULGARIS, SHOWING METHOD OF DEVELOPMENT OF NEW CULMS

This is a clump bamboo, and the new shoots develop close to the mother stem. Brooksville, Fla. (Photographed by R. N. Jones)

FIG. 1.—FINE GROWTH OF YOUNG BAMBOOS BENEATH MAGNOLIA AND LIVE-OAK TREES

These beautiful edible bamboos are near the residence of Rufus Fant, Anderson, S. C. (Photographed by David Fairchild)

FIG. 2.—GROVE OF THE GIANT TIMBER BAMBOO

The Barbour Lathrop grove, on the Ogeechee Road, near Savannah, Ga. The meanest shack is given dignity when nestled amid such surroundings. (Photographed by David Fairchild)

driven into the culms may injure them, and branding them with a hot iron or by force may do the same thing. About the best and simplest form of marking is that used by Robert Jones, who merely fastens a piece of light iron wire around the stem at about the height of a man's eyes. The wire is put on after the culm has attained its full size. Different combinations of wire represent different years.

In this connection, mention should be made of the remarkably rapid growth of bamboo shoots when they appear in the spring. A good many records of this phenomenon have been made in various parts of the world. C. C. Thomas, of the Office of Foreign Seed and Plant Introduction, made some very thorough studies of the giant timber bamboo at the Chico Plant Introduction Garden in 1921. This small grove is now about 16 years old, and many of the plants have attained a height of from 40 to 50 feet and as much as 12½ inches in circumference 18 inches from the ground. Mr. Thomas's studies of growth were made during June, July, and August, 1921. He devised a simple and effective means of measuring the culms. This was accomplished by placing a paper cap over the apex of the culm when it had reached a height too great to be measured from the ground. This cap was attached to a long string, and each time a measurement was made a knot was tied in the string. A light weight was attached to the string to keep it taut.

Mr. Thomas found that the greatest growth took place during the day, the average rate of elongation for a culm being 13.57 inches for a 12-hour period and 19 inches for a 24-hour period. The maximum increase in height for a 12-hour period was 19 inches, and for a 24-hour period 36 inches; for a 48-hour period the growth was 72 inches, or 6 feet. Mr. Thomas found that the total time required for a culm 40 feet in height to complete its growth and put out its leaves and branches after its emergence from the soil is five to six weeks. This is certainly a remarkable example of rapid growth and shows how important it is that there should be an abundance of food stored up in the underground portions of the plant when the season for growth begins.

BAMBOOS AS ORNAMENTALS

While there are many questions to be determined as to the future place of bamboos in this country so far as relates to their use for domestic and commercial purposes, there are few, if any, as to their place in landscape adornment. Some one has said that flowers must be hunted for, but bamboos spring into notice by virtue of their individual charm. There are a distinctiveness, a softness, and a grace about the bamboo that appeal to everyone. This is partly due to its novelty, for there is no other vegetation like it; yet it blends and harmonizes with practically everything with which it is associated.

In the Orient, where bamboos are abundant, the distinctive characters of the plants are not so noticeable, but in this country they seem to bring a breath of the age-old mysteries of the East, and the swaying and whispering of their delicate leaves and branches invoke a spirit of restfulness and peace. Even the blasé auto tourist,

who probably gives little or no thought to the trees and shrubs that he rushes past, pauses with astonishment and frequently with awe as the towering culms of the giant grass come into view on the Ogeechee Road leading out of Savannah, Ga. This is the Barbour Lathrop grove, many of the culms being now 60 feet or more high. A man entering such a grove for the first time is like an ant entering a wheat field, never having been in such a place before. The ant, accustomed to moving on smooth ground or in short grass, suddenly finds itself in a new world where everything is out of proportion.

Let us first speak of bamboos as garden plants. For anyone loving novelty and the great charm of trying new things the bamboo garden is to be unqualifiedly commended. In garden culture the plants are not difficult to grow. Each kind has its peculiarities, its whims, and its wants. Some are shy and easily kept within bounds. Others are bold, aggressive, and unless carefully watched not only overwhelm their neighbors but will take possession of the walks and roadways and even force their way into your kitchen or bedroom. All these things add to the interest in growing them and taming them.

As most bamboos are intolerant of cold it is in the milder parts of the country where bamboo gardens may be most highly developed. The South Atlantic and Gulf Coast States, California, and parts of Oregon give the widest scope for such development. Bamboo gardens may, of course, be maintained even as far north as Washington, D. C., but the number of species and kinds that may be utilized will be limited in these colder sections.

Henry Nehrling, of Naples, Fla., one of the pioneers in growing bamboos in this country and a great lover of these plants, has devoted a good part of a lifetime to their introduction and study. In speaking of bamboos for landscape effect Mr. Nehrling says:

> There is nothing that can compare with them in distinctness, in thrilling beauty and picturesqueness. The palm is the prince of the plant world and the bamboo everywhere is its close companion. Where we find the former we may look for the latter. It takes 10 to 15 and even 20 years to grow a palm into a fine tall specimen.
>
> The bamboo is a very conspicuous object in a few years, and at the age of 5 or 6 years it forms an impressive feature in the landscape. It grows everywhere with equal vigor, and its demands on the soil are few and easy to satisfy. While the palm is an aristocrat, looking best in close proximity to pretentious buildings and in large parklike grounds, the bamboo hides the small unsightly cabins and plain cottages and imbues them with as much beauty as the costly mansion of the wealthy. In parks clumps of bamboo look exceedingly rich and indescribably beautiful. What pictures of refined beauty the landscape gardener would be able to create with these giant grasses in the large parks of our northern cities if they were available to cultivation there! But, alas, they are not hardy and can only be grown successfully in our southernmost States and in California. Our southern parks and pleasure grounds should abound in them. They should be in every garden; at least one good specimen. Along lakes and streams they have no equal, their arching, wandlike stems hanging over the water in graceful masses. They look well as isolated specimens on the lawn, but they look better still in the foreground of noble evergreens, like *Magnolia grandiflora*, the Himalayan *Cupressus torulosa*, and our southern red cedar. A bench under a large bamboo is an ideal resting place after the day's work is over.
>
> And how charming it is when the glowing and graceful redbirds hurry through the green masses of foliage and stems or when the jocund mocking bird pours forth its sprightly notes from the top of a tall clump. The iris is frequently called the "orchid of the poor." With the same right we might

call the bamboo "the palm of the poor." It often hides the most dilapidated shack with a verdure and grace that are simply wonderful. A large clump of bamboo is always very conspicuous, very impressive. It creates a tropical effect even more striking than a palm. A large clump of bamboo you can see at quite a distance. This is not the case with most palms, if we except groups of coconut and royal palms.

No formal rules can be set down for the culture of these plants for ornamental purposes. The soil should be rich, deep, and well drained, not overwet or easily dried out. Due allowance, of course, must be made for the future development of each species and type. The large ones must have room and the smaller ones need to be planted and handled so as to get their full quota of air, moisture, and sunlight. Formal beds are not desirable. The plants will do best in informal groups or clumps. One need not be prevented from having a bamboo garden for lack of room. (Pl. XIV, figs. 1 and 2.) If half an acre is available all the better, but if there are only a few square rods off somewhere in a corner the plants may be placed there. For the lower half of Florida, southern Louisiana, and southern Texas the noncreeping or clump bamboos lend themselves best to garden culture and for ornamental planting generally.

Following are some of the more desirable forms suitable for regions where winter temperatures rarely go below 25° F.

Bambos vulgaris (more fully described on page 13).—A beautiful clump bamboo, growing to a height of 60 to 70 feet. Many of the culms attain a diameter of 3½ to 4 inches. The shoots put up in midsummer, and many of them remain bare of leaves during the winter. The straight culms are rather stiff, giving the clumps a somewhat rigid effect. A form sometimes called *B. thouarsii* is very desirable for clump planting. It seems to be more hardy than the vulgaris type, produces more and better foliage, and is not so stiff and formal. It has a stately and beautiful effect when planted near tall buildings and when mixed with evergreen trees.

Bambos tulda (see page 12).—A quick-growing, beautiful, and graceful bamboo, forming dense clumps easily kept within bounds. The plant is tender, but even if cut down by frost it quickly recovers. It should by all means have a place in every bamboo garden. Reproduces either by division or seeds. Seed must be imported. Under favorable conditions *B. tulda* will grow to a height of 70 or 80 feet. Planted along watercourses or near lakes, it gives the landscape a striking tropical appearance.

Bambos balcooa.—An Indian species recently introduced (S. P. I. No. 51361) by the United States Department of Agriculture. This bamboo is tender. It has more of a drooping habit than *B. tulda* and is also more spiny. The leaves are large, and the culms attain a height of 60 to 70 feet. At Brooksville, Fla., when the temperature fell to 25° F. the plant lost most of its leaves but quickly recovered. It is a handsome, graceful bamboo, giving a decided tropical effect to the landscape. It may be grown from seeds or by division of the clumps. In the warmer sections of Florida this bamboo may be planted for avenue effect and for roadway adornment.

Bambos arundinacea.—A tropical species, but will likely stand light frosts. Suitable for the southern portions of Florida. The plant grows to a height of a hundred feet, the culms being 6 to 7 inches in diameter. It is very thorny and is sometimes used in the growing state for fences and hedges. The United States Department of Agriculture has introduced this bamboo under four separate numbers (S. P. I. Nos. 21317, 21837, 22487, and 27490), but it has done little yet in the way of proving its usefulness as an ornamental.

Dendrocalamus strictus.—A beautiful giant cane bamboo with drooping feathery foliage. Somewhat generally introduced especially in southern Florida. The United States Department of Agriculture has imported it under 10 or 12 different numbers, the last being S. P. I. No. 56532. This species will stand considerable frost, is readily propagated by division, and in good soil makes a rapid growth. As an ornamental form for clump plants in dooryards and on villa sites this and the next species can hardly be excelled.

Dendrocalamus latifolius.—This is similar to the last, but with darker and heavier foliage. It stands considerable frost, and a clump of it gives a wonderful tropical effect to the landscape.

Several other species of Dendrocalamus have been introduced and should be mentioned as worthy of trial for ornamental planting. *D. hamiltonii* (S. P. I. No. 53909), *D. sikkimensis* (S. P. I. No. 56457), *D. longispathus* (S. P. I. No. 54311), and *D. brandisii* (S. P. I. No. 54429) are some of the promising sorts.

Guadua angustifolia (S. P. I. No. 42066).—This has proved one of the most vigorous and attractive of the clump bamboos at Brooksville, Fla. It was first introduced by the United States Department of Agriculture in 1914, and a second introduction followed in 1916. Notwithstanding the fact that the soil at Brooksville is thin and poor this bamboo made remarkable growth, reaching a height of more than 50 feet by 1921, when the clump was blown over by a West Indian hurricane. The foliage is very beautiful, producing a wonderful feathery effect like giant ostrich plumes.

Some of the more hardy bamboos suitable for a great variety of landscape adornment, screens, windbreaks, and shelter belts will now be briefly described.

Bambos nana var. *alphonse-karri* (S. P. I. Nos. 9056 and 42670).—A beautiful ornamental, forming large dense clumps. The young canes are striped with white and pink, the older stems yellow with green stripes. This is a dwarfish bamboo, sometimes reaching a height of 10 or 12 feet. It is useful as an ornamental where low forms are desired. It will stand considerable frost and will serve a useful purpose in screening fences and low buildings and for clump effects in gardens and grounds.

Arundinaria simonii (S. P. I. Nos. 3223 and 42650).—One of the most striking and tallest of our hardy bamboos. Stems 20 to 25 feet in height, forming dense clumps. The leaves are long and slender and are sometimes striped white. This bamboo is worthy of cultivation in nearly all of the Southern States and the warmer parts of the Pacific Coast States. The canes are useful for light stakes and similar purposes.

Sasa argenteo-striata (*Bambos argenteo-striata;* S. P. I. No. 42669).—A vigorous-growing clump of bamboo with culms reaching a height of 25 to 30 feet. When planted thick it makes a very effective windbreak. Hardy in most of the South Atlantic and Gulf Coast States and the warmer parts of California and the Pacific Coast. A form of this bamboo known as *argentea* is much planted in Florida, where it is used in ornamental clumps and for screens and windbreaks.

Sasa japonica (*Arundinaria japonica;* S. P. I. No. 42651).—Arrow bamboo of Japan. A handsome hardy species forming compact clumps 10 to 14 feet high. The plant is hardy as far north as Washington, D. C., where a large clump may be seen growing on the west side of the grounds of the Department of Agriculture. The leaves of this bamboo are frequently a foot long, dark green in color, and 2 inches wide. This variety is worthy of widespread use, first, on account of its highly ornamental nature and, second, for the reason that its canes are useful for many purposes, including plant stakes, canes, and light fishing rods. *Sasa japonica* is a good winter ornamental and produces a striking effect with its large evergreen leaves when covered with snow.

Sasa disticha (*Bambos disticha*).—A dwarf bamboo with small, narrow leaves. This is a beautiful little decorative bamboo and forms a striking picture on the lawn or in the garden. The plant may be used for hedges and for mixing with other larger growing types for landscape effects. Suitable for most of the Southern States and for the warmer sections of the Pacific coast.

Sasa pumila (*Arundinaria pumila;* S. P. I. Nos. 41924 and 52673).—A handsome ornamental dwarf bamboo, hardy in practically all the Southern States and as far north as Virginia. The culms are slender and seldom grow more than 2 feet high. The leaves are 4 to 5 inches long. Useful as garden and border plants, especially when mixed with some of the tall-growing ornamental grasses.

In addition to the foregoing, all the bamboos described in connection with cultural types lend themselves well to landscape and ornamental plantings. Both the tall-growing and the low forms of Phyllostachys produce beautiful landscape effects and are also valu-

able for screening buildings and securing privacy where homes are in too close proximity to busy streets. These bamboos may very effectively be used for screens along railroad rights of way, trolley-car lines, and highways.

BAMBOO DISEASES

Bamboos as a group are remarkably free from serious diseases and destructive insects. Many of the species are attacked by these enemies, but with the possible exception of bamboo smut there are no widespread epidemics reported anywhere in the world such as occur in connection with other plants. The fungous enemies of bamboos that have been noted as attacking plants in this country may first be briefly reviewed.

BAMBOO SMUT

Bamboo smut (*Ustilago shiraiana* Henn.) is caused by a minute parasitic fungus related to the one occurring on corn. Other smut fungi attack wheat, oats, and several other kinds of grasses. The smut of bamboo was introduced into this country about 15 years ago in shipments of plants from Japan. When it appeared at the Chico Plant Introduction Garden it was immediately taken in hand and quickly extirpated. Since this first outbreak in 1910 there have been no further reports of the disease in this country except on two plants that had been kept for study in one of the pathological greenhouses of the United States Department of Agriculture at Washington, D. C. These plants were destroyed in 1917, and there has been no recurrence of the trouble.

The smut always occurs on the young and growing shoots. The shoots appear somewhat swollen, and growth is arrested. Later the sootlike masses of spores, or propagating bodies, break through the tissues, producing an effect that can not be mistaken for any other trouble. No evidence has been obtained here that the disease is spread by the spores. The way it showed itself, at about the same time each year, would suggest that the mycelium or vegetative part of the fungus lives perennially in the rhizome. Eradication is the only remedy, and the eradication must be complete. It will not suffice to cut down the plants. All rhizomes must be dug and burned. As bamboo plants are no longer allowed entry into the United States except under strict quarantine regulations, it is not likely that there will be further trouble with smut. All those interested in bamboos, however, should be on guard against this pest, and if it appears no time should be lost in destroying the affected plants. The smut is not known to attack any bamboos outside of the Phyllostachys group. In other words, it is a limited parasite, like other smuts.

BAMBOO RUST

More than a dozen species of rust fungi have been reported as occurring on bamboos in different parts of the world, but so far only one (*Puccinia melanocephala* Syd.) has found its way to this country. The rusts are a large group of parasites, of which several species attacking grasses and grain crops are examples. Most rusts are dangerous and destructive and are controlled with difficulty. The

species attacking certain bamboos of the Phyllostachys group was first noted in the United States four or five years ago and so far seems to be confined to Florida and one place in Georgia. The disease attacks the leaves, causing numerous brown powdery spots on the under surface with correspondingly yellow discolorations on the upper side. When badly affected the leaves shrivel and dry up. The powdery dustlike material on the under surface of the leaves forms the spores, or reproductive bodies, of the fungus. While at Brooksville, Fla., in 1921, the teleutospores, or winter form, of the fungus were found by the writer on old leaves that had fallen to the ground. A few weeks later the uredo, or red-rust form, began to show on numerous plants. It is this form that causes most of the injury. The life history of the fungus has not been studied, so nothing is known as to its life cycle. Whether intermediate stages occur on other host plants, as is the case with certain grass rusts, remains to be determined. The effect of the rust is to check growth by injury to the leaves, many of which are shed prematurely as a result of the disease.

In view of the present limited distribution of the rust it is important to exercise every care to prevent its spread. To this end care must be taken in propagating only from rust-free stock. If the disease appears the rusted leaves should be raked up and burned. It may even be desirable to cut all plants back to the ground and when the brush is dry burn it. This has been done in some cases, using a blast torch and oil to aid in the burning. Plats burned over in this way early in spring soon recover their growth, and if there is no infectious material near by the plants are likely to remain free from rust for a time at least. There is no experimental evidence to show that the rust can be completely eradicated by the burning method, but even where infectious material is near, cutting and burning greatly aid in holding the disease in check, being particularly applicable to the small-growing Phyllostachys.

MELANCONIUM CULM DISEASE

A disease which has been noted for several years at the Barbour Lathrop bamboo grove, near Savannah, Ga., shows on large culms when these are 40 to 50 feet high and 2 to 4 inches in diameter. The internodes near the ground become discolored, turning purplish black and sometimes brown. The discoloration is not sharply defined and gradually extends around and upwards until the whole joint is affected. The culm eventually dies and the leaves dry up. The wood of the discolored part is found to be permeated with mycelium threads. These threads constitute the vegetative parts of a fungus found penetrating the tissues of the wood. When portions of the diseased wood are cut out under properly safeguarded conditions and placed in a moist, warm, sterile chamber large quantities of mycelium soon develop. This gives rise to quantities of spores.

A similar disease has been reported from Italy (*14*) as attacking several kinds of bamboo. The fungus causing the Italian disease has been identified as *Melanconium bambusae*, and the one occurring here appears to be the same. It is doubtful whether these fungi attack healthy plant tissue. The culms at Savannah may have been previously weakened in some way.

Invasion of the fungus has been noted where the wood has been bruised or injured by cuts. Attempts to mark the culms in various ways so as to determine their age in after years have brought about infection. Lack of a proper food supply may be another contributing cause. So far the disease has not proved serious, but it should be watched for, and where it appears the diseased culms should be taken out and destroyed. Precautions should also be taken in the matter of culm injuries, especially when the bamboos are making rapid growth.

BAMBOO INSECTS[2]

Most of the insects found infesting living bamboo in the United States are scales, and practically all feed by sucking juices from the leaves and stems. Other than scales, mealybugs, aphids, and mites are known to attack bamboo in this country and are sometimes sufficiently injurious to require remedial or control measures. In such cases the course to be followed will be governed by the degree of infestation, the condition of the plant, and the purpose for which it is grown. Sometimes it may be wise to cut down and burn all the infested material. Usually, however, the removal and burning of the dead and of the more heavily infested living portions of the plants that can be spared, combined with the spraying treatment appropriate for the species of insect concerned, as described below, will be satisfactory.

Where the species of insect mentioned has other host plants in the vicinity, as is the case at least with some of these pests, it will be advisable to examine the other plants for the insect's presence or appearance and endeavor to prevent these plants from becoming a source of infestation for the bamboo.

BAMBOO SCALE

The adult female of the bamboo scale (*Asterolecanium bambusae* Bdv.) is observed as an oval, moderately convex scale. It is from 2 to 2½ millimeters ($\frac{1}{12}$ to $\frac{3}{32}$ inch) long and 1½ millimeters ($\frac{1}{16}$ inch) wide. The scale is smooth and glossy in appearance, semitransparent and colorless or tinged with green or yellow. The marginal fringe consists of a double series of short, pinkish, glossy filaments which appear in pairs.

The insect is found at many places in California and in Florida and perhaps other Southeastern States. It is also frequently intercepted at quarantine. The bamboo scale attacks *Bambos vulgaris* and the persimmon (*Diospyros* spp.). Sometimes infestations are heavy. In California the scale is not found injurious to the host to a marked degree, and little production of honeydew and smutting is recorded.

In control, G. F. Moznette has found an oil emulsion consisting of paraffin oils and fishoil soap to be effective. This oil emulsion is prepared as follows:

Red engine oil	1 gallon.
Water	½ gallon.
Potash-fishoil soap	1 pound.

[2] The matter relating to bamboo insects was prepared by William Middleton, of Forest Insect Investigations, Bureau of Entomology, which investigates insects affecting hardy shrubs and to which inquiries about them should be addressed.

The oil, water, and soap are placed in a tank and heated until the contents come to a boil. Just before boiling a brown scum appears on the surface of the mixture, and as the boiling starts the brown scum will begin to disappear. At this stage the heat should be cut off and the entire mixture pumped twice under a pressure of about 60 pounds while still very hot. The first pumping may be made from the tank into a second container. The second pumping can then be made back into the original container or into barrels or other storage receptacles.

Heating the mixture is not sufficient to produce an emulsion. The mixture should be boiled, but it is not necessary that the boiling continue more than a few minutes. In pumping, the entire contents should pass through a pressure pump twice. A rotary pump should not be used. Stirring will not produce a proper emulsion, nor should the mixture be allowed to cool before it is pumped.

This stock emulsion is to be used diluted at the rate of 1 part to 66 parts of water. Several sprayings are necessary, about 10 days apart, employing pressure to reach as many scale insects as possible.

ASTEROLECANIUM MILIARIS LONGUM

Another scale (*Asterolecanium miliaris longum* Green), closely related to the bamboo soft scale, is found on bamboo in Florida. This species apparently infests only the leaves, attacking both sides. The scale is long and narrow, from 1¼ to 1½ millimeters ($\frac{1}{20}$ to $\frac{1}{16}$ inch) long by about ½ millimeter ($\frac{1}{50}$ inch) wide, and is moderately convex. It is glossy in appearance and, like the preceding species, varies from semitransparent and colorless to translucent tinged with yellow or green. The posterior end is drawn out into a blunt point, and the marginal fringe is short and imperfect.

This scale is recorded only from bamboos in Florida, where it is found at Coconut Grove, Key Biscayne, Miami, Oneco, Orlando, and Tarpon Springs.

The method of control used for the preceding species will probably be found satisfactory.

COTTONY BAMBOO SCALE

The cottony bamboo scale (*Antonina crawi* Ckll.) has been found on bamboos in New Jersey and California. The adult female scales are from one-eighth to nearly one-fourth inch in length. The scales are completely covered with a thick, white cottony coat which makes them very conspicuous. They collect in rather large masses in the leaf axils of the canes.

The mature females are found in May and June, and the young settle on the leaves and tender growth. In the winter the insects are found in the leaf axils of the harder growth.

The cottony bamboo scale is recorded as quite injurious when abundant, rendering the bamboo unsightly and stunting its growth. It appears to prefer small suckers to large hardy plants.

In California the scale is found in the southern and central parts of the State and in New Jersey at Riverton. It appears to be restricted to bamboo and is found at least in both black-joint bamboo (*Phyllostachys puberula nigra*) and golden Japanese bamboo (*Phyllostachys aurea* Carr.).

The adult scales protected by their waxy covering are hard to kill by sprays, but frequent sprayings under good pressure with oil emulsion or soap solutions (soap about 1 pound to 10 gallons of water) will kill the young insects as they appear.

LEUCASPIS BAMBUSAE

Another Japanese pest of bamboo found in the United States is a scale technically known as *Leucaspis bambusae* Kuwana. This scale has been found on bamboo received from Japan in New Jersey at Riverton. It is also established in Florida at Brooksville, Fruitland Park, Glen Saint Mary, Miami, and South Jacksonville.

The female scale is from 2 to 3 millimeters ($\frac{1}{12}$ to $\frac{1}{8}$ inch) long, slender, with the sides nearly parallel. It is convex, rather thick, and although usually straight is sometimes curved. In color it is snow white to dirty white or light gray, with a brownish cast skin incorporated in the scale at one end.

The scale is recorded specifically from the giant timber bamboo (*Phyllostachys bambusoides*), and its economic importance seems questionable. In one heavy infestation little damage appeared to have been done, and it was controlled by cutting back the bamboo. Several sprayings with oil emulsions at intervals should also be of considerable value

LONG-TAILED MEALYBUG

The long-tailed mealybug (*Pseudococcus adonidum* L.) is widely distributed in the United States and attacks many plants. It is common on ornamentals. The female adult is oval in shape and from 2.4 to 3 millimeters ($\frac{1}{10}$ to $\frac{1}{8}$ inch) in length. The body is grayish to light yellow in color and covered with a fine, powdery, waxlike whitish secretion. The species is easily distinguished by the unusually long filaments or tassels. Those around the margin of the body are often equal in length to half the width of the body. The four posterior tassels give the insect the appearance of having a long tail, and the middle pair are often longer than the body. This mealybug occurs almost everywhere in the United States and may be found on nearly all host plants.

The control of mealybugs is rendered difficult by the presence of their waxy protective covering. Water under strong pressure is useful, and frequent sprayings, using the oil emulsions and soap solutions already mentioned, or a nicotine-sulphate soap solution, will be found valuable, especially when applied under pressure. The nicotine-sulphate soap solution should be prepared as follows:

Nicotine sulphate	1 to 1¼ teaspoonfuls.
Soap (fishoil preferred)	1 ounce.
Water	1 gallon.

A few plants may be treated by scrubbing them with soapy water, using a brush.

Ants are usually largely responsible for the dissemination of mealybugs, and it is important to destroy them. The ants' nests should be located and holes from 8 to 12 inches deep made in the vicinity about 1 foot apart. A tablespoonful or two of carbon disulphide, a poisonous and inflammable liquid, should then be poured into each hole, the opening closed, and the ground covered with some gas-proof material or the surface kept watered for several days.

BAMBOO PLANT-LOUSE

The adult plant-louse, known as *Myzocallis arundicolens* Clarke, is about one-tenth inch long and pale yellow in color. Under the microscope the antennæ, sides of the thorax, two rows of tubercles on the abdomen, the wing veins, and feet are light brown or dusky. The young forms show little or no markings. The species is found almost everywhere that bamboo is grown. It has been collected at Berkeley, Santa Barbara, San Francisco, and Sacramento, and probably occurs generally in central and southern California. It is found on the under sides of the leaves or blades of bamboo, often in large colonies, and doing much damage by weakening the plants and causing a smutting of the foliage.

The nicotine-sulphate soap solution mentioned under the preceding species is very valuable in combating plant-lice.

BAMBOO MITE

Bamboo in Florida and California is infested by this creature (*Stigmaeopsis celarius* Banks). This animal somewhat resembles in appearance the red spiders of the genus Tetranychus and makes small white webs on the bamboo. It chiefly infests Phyllostachys, but is also sparingly found on several related genera. No native vegetation has been found attacked.

The injury caused by the mite does not appear to be serious; no bamboos are recorded as killed or suffering severely, and the species is not noted as injurious in Japan, its native home.

The mites are confined to the leaf sheaths for from 8 to 10 months and are not found on the stems near the ground or in rhizomes or parts of the plant below ground. The migration period of the mite occurs in May and June.

For control in propagation the rhizomes of the preceding year's growth should be lifted in November and December, when the plants are dormant, selecting those rhizomes containing living eyes or buds. These should be treated by immersing them for 10 minutes in hot water at 122° F. and then heeling them in sand previously heated to 167° F. for one hour, or in sawdust, and kept cool until planting time in the spring.

PRIONID ROOT-BORER

At Burroughs, Ga., a bamboo grove is reported as infested by a prionid root-borer (*Prionus* sp.). This roundheaded larva feeds on the roots and rhizomes of the bamboo, but the injury does not appear to be very serious. Too little is known of this insect to justify any suggestions for control here.

JAPANESE SHEATH MITE

(*Tarsonemus bambusarium* Banks)

In addition to the foregoing insects, the writer of this bulletin desires to call attention in a brief way to a mite which has been under observation and study at the Brooksville Plant Introduction Garden since the spring of 1917. This mite was discovered by David Fairchild, who made brief notes on its appearance and numbers. During

the past five years its life history has been pretty thoroughly studied, and satisfactory methods of control have been worked out. For a number of years it was impossible to account for the presence of the creature at Brooksville and nowhere else in the county. Suspecting that it might occur on related plants, such as sugarcane, sorghum, and native grasses, these were carefully studied, but no evidence of the presence of the mite could be found. Attention was then turned to Japan, and within the last two years the mite has been found on specimens received directly from several localities in that country. There can no longer be any doubt that the mite was introduced from Japan when plants were brought to this country in 1909 which soon thereafter were sent to Brooksville.

The mite in various stages was submitted to Dr. Nathan Banks, of the Museum of Comparative Zoology, Cambridge, Mass., who decided it was a new species and named it *Tarsonemus bambusarium*.

The sheath mite, as the name indicates, is found the greater part of the year snugly ensconced in the tightly clasping sheaths which form the lower portion of the leaves. Taking hold of the leaves of any of the Phyllostachys bamboos, to which this mite is confined, and pulling them apart, it is found that they separate easily. As each leaf is separated there will appear at last the stalk of the terminal leaf. It is usually around this tender moist stalk that the mites are found in great numbers. They are flattened, reddish, almost microscopic creatures admirably adapted in every way to the conditions under which they live. The mites easily succumb to a little dryness; hence they do not long survive when the bamboo branches dry up. They live by sucking the juices from the tender growing parts. This causes the forming branches and leaves to abort, with the result that growth is checked.

When the ground is rich and the plants are growing strongly, the writer has never been able to find that the mite produces any measurable effect on growth. A good many experiments have been made in colonizing mites on the young growing plants under control conditions. Plants thus colonized grow as well as though no mites were present. Where growth is poor for any reason, such as drought or lack of proper cultivation, mites are likely to cause damage by producing many blind branchlets; that is, branchlets where the terminal buds are killed. For the greater part of the year, 8 or 10 months at least, the mites are confined entirely to the leaf sheaths. Many searches have been made for mites during the summer, fall, and winter months, but in no instance have they been found outside of the leaf sheaths. The period of migration of the mites begins the latter part of April at Brooksville and continues through May and June. Fortunately, this period is not coordinated with the proper time for the best propagation of the plants by the rhizome method, as pointed out in discussing methods of propagation. The propagating period is February and early March. This is fortunate, as it makes it practicable to carry on propagation work when the mites are confined to the leaf sheaths.

A good many experiments have been made in efforts to find simple and economical ways of ridding the plants of mites. The best results have been obtained from treatment with hot water. This method was developed at Brooksville by R. N. Jones and has been

modified somewhat in connection with our laboratory and greenhouse work in Washington. Large numbers of plants treated at Brooksville have been sent to Washington and planted in the department's plant-inspection house and in the test garden at Bell, Md. In all cases it has been found that a treatment of five minutes in water at a temperature of 50° C. (122° F.) kills the mites but does not injure the plants or rhizomes. Many thousands have been treated in this way, and no such plants have been found to be infested. So far, the mite has been confined to the garden at Brooksville, and as these plants are soon to be destroyed and the garden abandoned it is hoped that there will be no further trouble from this pest.

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